ENGINEERING MANAGEMENT SUPPORT INC.

7220 West Jefferson Avenue, Suite 406
Lakewood, CO 80235

Telephone (303) 940-3426
Telecopier (303) 940-3422

October 6, 2015

VIA: Electronic and U.S. Mail

U.S. Environmental Protection Agency
Region VII SUPR/MOKS
11201 Renner Boulevard
Lenexa, KS 66219

ATTENTION: Mr. Bradley Vann

SUBJECT: Responses to EPA's and Other Agencies' Comments on the Isolation Barrier Alternatives Analysis West Lake Landfill Superfund Site, Bridgeton, Missouri

Dear Mr. Vann,

Pursuant to your July 23, 2015 electronic mail to me, as amended by our subsequent correspondence, Engineering Management Support Inc. (EMSI), on behalf of Bridgeton Landfill LLC, hereby submits responses to the EPA and other Agencies' comments on the Isolation Barrier Alternatives Analysis – West Lake Landfill Superfund Site dated October 10, 2014 (the IBAA).

Over the one-year period since we submitted the IBAA, Bridgeton Landfill LLC has performed numerous additional evaluations related to the occurrence of the subsurface reaction in the South Quarry and heat extraction technologies to control potential heat migration from the South Quarry area of the Bridgeton Landfill. For example, Bridgeton Landfill LLC significantly expanded the scope of the initial heat removal pilot test, prepared an August 2015 report of the initial results of the expanded heat removal pilot study, and prepared a September 2015 Evaluation of Remedial Action Approaches for Hot Spot Remediation. We have included copies of these evaluations as part of the responses to comments on the IBAA.

Bridgeton Landfill LLC also is currently in the process of preparing a technical evaluation of a heat extraction line to control temperatures within the Neck Area, which is scheduled to be submitted on November 1, 2015. As noted within the comment responses, the completed and upcoming heat extraction studies offer additional information relevant to the barrier analysis.

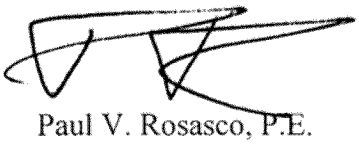
In addition, the West Lake Landfill Operable Unit-1 (OU-1) Respondents have conducted additional investigations of the extent of radiologically-impacted material (RIM) in the

southern and southwestern portions of OU-1 Area 1 (the Phase 1D investigation) and are completing additional characterization work within Areas 1 and 2.

Consequently, some of the original comments on the IBAA may no longer be directly relevant or may have been addressed through performance of other work at the Site. For example, it is likely that comments and questions related to the initial heat extraction pilot test that occurred in gas extraction well GIW-4 are no longer of particular relevance because this initial heat removal pilot test was subsequently expanded to encompass many more heat removal points covering a much larger area with significantly more temperature monitoring points than were included in the original single well test. In addition, it is anticipated that the modeling and design work that will be submitted with the November 1, 2015 technical evaluation will directly translate into any thermal barrier configuration that may be conceived. Similarly, completion of the Phase 1D investigation will provide data necessary to address those comments related to the extent of RIM in Area 1. A report of the results of this investigation is currently being prepared and will be submitted to EPA.

If you have any questions or desire additional information related to the responses to comments, or any other aspect of the work being performed at the Site, please do not hesitate to contact me.

Sincerely,
ENGINEERING MANAGEMENT SUPPORT, Inc.



Paul V. Rosasco, P.E.

Attachment: Responses to Comments on the Isolation Barrier Alternatives Analysis – West Lake Landfill Superfund Site

Distribution:
Lynn Juett – EPA Region VII
Alyse Stoy – EPA Region VII
Jeff Field – EPA Region VII
Brian Power – Bridgeton Landfill LLC
Joe Benco – Republic Services, Inc.
Jessica Merrigan – Lathrop & Gage
Russ Eggert – Lathrop & Gage
Nick Johnson – Lathrop & Gage
Dan Feezor – Feezor Engineering, Inc.
Peter J. Carey – P.J. Carey & Associates
Mike Bollenbacher – Auxier & Associates
Rolph Davis – LGL Limited

Responses to Agency Comments
Isolation Barrier Alternatives Analysis, West Lake Superfund Site, Bridgeton, Missouri

As part of the responses to the comments, we must note that some of the commenters referred to the subsurface smoldering reaction that is currently occurring in the South Quarry portion of the Bridgeton Landfill as a "fire." Use of the term "fire" suggests that flames and/or smoke are present, which is not the case. The reaction does entail pyrolysis and/or other chemical reactions and as such is exothermic resulting in production of heat, but the reaction is not generating flames or smoke. The reaction that is occurring in the South Quarry is therefore more appropriately termed a subsurface smoldering reaction (SSR), subsurface heating event, subsurface smoldering event (SSE), or an exothermic reaction.

USEPA Region 7 Comments

General Comments:

1. The concept of a heating event within radiological waste combined with its effect on the radiological conditions, specifically radon flux at the surface is complex. The specific arguments postulated in this document in relation to the heat's effect on the radiologically- impacted material (RIM) and therefore radon flux in Attachment A are well thought out and present plausible scenarios considering an event occurring is a low probability. That said, several specific comments are provided below with regards to Attachment A (Radon Flux Analysis) which warrant consideration and/or addressing in the text of this document.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

We appreciate the agency's review and evaluation of the assessment and agree that, despite the limited probability of such an event occurring, a careful evaluation is necessary. Responses to the specific comments related to radon flux are provided in italics below.

2. Long-Term O&M and Monitoring. The report did not consider long-term operation and maintenance {O&M) and monitoring associated with the various alternatives. Alternatives 1, 3, and 4 propose the operation of liquid heat extraction systems that may pose several technical challenges (e.g., moving a large amount of liquid, pumping systems, heat exchangers, liquid loss, etc.). Additionally, this heat extraction system, if it

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is deployed, may require operation for several years, and the durability/longevity of this technology is unclear since we are not familiar with its use at any landfills in the past. Long-term monitoring (e.g., waste temperature, settlement) will also be needed for waste located north of the barrier for Alignment 1, 3, and 4 (as discussed in Section 2.4, Attachment C of the IB Alternatives Report). Alignment 2, although considered infeasible in the report by Feezor, is the only Alignment for which IB-related long-term monitoring of OU-1 would not be needed. Please review this information and amend the document accordingly.

Response: *Long-term operation and maintenance and monitoring will be considered. Detailed plans and specifications have not yet been developed. However, at a conceptual level, discussions can be added which will anticipate the needed operation and maintenance issues and the needed monitoring. However, until the final design is completed, these items will be preliminary and tentative, requiring further refinement in the future.*

3. Technical Feasibility. The EPA considers technical feasibility to mean 'able to be constructed, and effective for its intended use. It would logically follow that there would be little or no purpose in selecting and constructing an IB alternative that could be built, but isn't proven effective in withstanding or containing an SSE. Both Alignment 1 and 3 entail installing a 45ft to >100ft deep concrete wall spanning the entire waste depth along the proposed Alignments. The report stated that "although construction of a concrete barrier is considered to be feasible, installation of a non-deformable barrier within a matrix of solid wastes is an application which has not previously been applied or demonstrated in solid waste, so uncertainty as to the success of such a barrier exists." It is unclear how these Alignments were determined to be technically feasible despite a lack of previous documentation or successful demonstration/application. An analysis of the efficacy of Alignment 4, based on referenced literature and documentation, is needed to determine if it is technically feasible. The EPA understands that a limited field pilot effort was conducted for a heat extraction well similar to those proposed in Alignment 4, but the scope and duration of this effort was limited. Alternative 2 is proven and well documented technology; therefore, it is the only demonstrated feasible technology option included in the report. Please review this information and amend the document accordingly.

Response: *To our knowledge, there are no established technologies for a thermal isolation barrier and we are not aware of any technologies for which application of a subsurface thermal isolation barrier have been demonstrated to be effective or implementable. None of the thermal isolation barrier options being considered for the West Lake Landfill have ever been implemented before, including an air gap barrier, which although implemented as an above-grade feature at another site has never been implemented as a subsurface feature. Therefore, none of the options have previously been demonstrated and therefore found to be effective or implementable.*

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Although none of the options have been previously demonstrated, a determination of the likely effectiveness and implementability of the potential alternatives can be made based on basic engineering principles and application of the specific technology or similar technologies for other purposes. Although not the same as an application relative to an SSE in municipal solid waste, the options being considered have been applied for somewhat similar purposes and/or in somewhat analogous materials. For example, heat extraction using circulating fluid is commonly performed for geothermal energy production. Use of structural concrete containment units to isolate materials with high heat or radiation is commonly employed in the nuclear power industry. Reinforced concrete walls are commonly used for slope retention. The engineering principles associated with these applications can be extrapolated to evaluate the estimated effectiveness and anticipated implementability of such technologies as applied to temperature control and subsurface waste stability at the Bridgeton Landfill. The design methods used for these types of applications can be applied to the design of one of these alternatives once the design criteria are established. Comments provided by the USACE suggest that the Corps considers both a slurry wall and the heat extraction option to be technically feasible.

4. Impact of RIM Excavation and Relocation. Three of the proposed Alignments would entail excavation and relocation of RIM. The estimated amount and impact of RIM excavation and relocation on risk/human health should be quantitatively evaluated for the four proposed Alignments, to the extent possible. Also, the amount of RIM remaining south of the barrier should be estimated for each Alignment, as recent investigations have demonstrated to the EPA that the extent of RIM has not yet been fully delineated. Benefits and drawbacks of RIM relocation off-site may be important to discuss in these Alignments as well, including any potential special handling, manifesting, and transport needs. Please review this information and amend the document accordingly.

Response: *The most logical method for evaluation of the extent of the occurrences of RIM is to complete the Phase 1D investigations and the upcoming additional characterization of Areas 1 and 2 and to use all of those data along with the results of the prior Phase 1, RI and NRC investigations to develop a preliminary revised estimate of the extent of RIM. A final determination of the extent of RIM will be performed as part of an update to the "complete rad removal" alternatives using the procedures previously described in the Supplemental Feasibility Study (SFS) report during development of the Supplemental SFS report.*

A preliminary revised estimate of the extent of RIM will be developed as part of preparation of the comprehensive Phase 1 report. The results of this evaluation can be used to estimate the amount of RIM that may be encountered during construction of each of the potential IB alternatives. The revised RIM estimate would also be used to estimate the following:

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- *The amount of RIM that may be relocated during possible installation of each IB alternative;*
- *The amount of RIM that may remain on the south side of the alternative IB alignments;*
- *The potential risks associated with construction and possible removal and relocation of RIM during installation of each IB alternative; and*
- *The potential long-term risks that may occur if any RIM were to remain outside (south) of each alternative IB alignment.*

A final determination of the extent of RIM will be presented in the Supplemental SFS report.

5. No Action Alternative. In general, more data and information are needed to assess the likelihood and impact of SSE migration into OU-1. The following comments are provided that could help to better describe and understand the migration of an SSE.

a. The report states *"due to the overall thinner nature of the waste materials in Area 1, the effective rate of heat dissipation in the vertical direction will be approximately 25 times greater than the rate observed in the South Quarry area of the Bridgeton Landfill. It is doubtful that any significant pyrolysis would occur at these shallow waste depths due to the lack of insulation. Such behavior would be consistent with observations at other sites that indicated no pyrolysis in waste depths of less than 60 ft."* It is acknowledged that a shallower waste thickness would likely promote heat dissipation. The basis of the magnitude (25 times) of increase in heat dissipation could not be assessed due lack of details presented in the report. Similarly, more details on "observations at other sites" made in the report are needed to assess the conclusion pertaining to the improbability of pyrolysis in waste depths of less than 60 ft. We note that elevated temperatures (greater than 200 °F) have been observed at waste depths as shallow as 40ft. We reference data from TMP-7R in the Bridgeton South Quarry over its operational lifetime (ending April 2014) that contradict this statement and merits revision.

Response: *The report was not intending to imply that a quantitative design calculation has been performed but rather is based on a qualitative assessment of field observations of temperature conditions in the South Quarry portion of the Bridgeton Landfill. Temperature and heat dissipation are not equivalent and temperatures in the South Quarry portion of the landfill are significantly influenced by the depth of waste, gas and liquid collection patterns. The depth of waste is much greater in the South Quarry (200+ feet) compared to the northern area of the North Quarry. The lesser thickness of waste in the northern portion of the North Quarry will result in much less heat generation per planimetric area. In addition, the lesser waste thickness also results in the presence of energy losing boundaries on both the top and bottom that are much closer together,*

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yielding in a higher rate of dissipation of heat energy (relative to the South Quarry). This will result in lower temperatures occurring within the waste mass in the northern portion of the North Quarry. Bridgeton Landfill is continuing to investigate and monitor temperature conditions in and near the South Quarry portion of the landfill and has also undertaken a heat extraction pilot test. Data obtained and evaluations performed for these investigations will be considered and incorporated as appropriate into future evaluations of potential SSE occurrence in Areas 1 and 2 as appropriate.

The elevated temperatures at a depth of 40' in TMP-7 are believed to be attributed to lateral heated gas transport rather than the presence of a heating event at that depth. Shallow waste has a much higher gas permeability than deeper waste creating a preferential pathway for gas movement.

The Countywide Landfill has experienced a large SSE. The SSE occurred entirely in a section of landfill that was approximately 210 feet deep while an adjacent section that was about 100 feet deep was never affected by the SSE. Unlike Bridgeton Landfill, there was no "neck" present to provide containment of the SSE; waste thickness alone seemed to be the reason that the SSE did not move into the adjacent 100 foot-thick area. This is believed to be attributed to the reasons described in the first paragraph of this response. Additional detail on the Countywide Landfill can be provided at EPA's request.

b. The presence of large soil berm in the North Quarry should not be relied upon in any design documents until its presence and details (e.g., dimensions and depth location) are confirmed.

Response: *The presence of a possible soil berm in the lower portion of the North Quarry will not be considered further.*

c. The report states that *"review of the temperature profiles from temperature monitoring probes indicate that in the northern part of the South Quarry, the heat generating material occurs at elevations of greater than or equal to approximately 360 to 380ft above mean sea level (amsl). The occurrence of heat generating material at elevation of 360 to 380 ft amsl may reflect the limit of the depth of reactive waste materials or may reflect thermal constraints associated with the configuration of the South Quarry (i.e. dissipation of heat through the bottom and sides of the quarry wall which control the vertical position of the pyrolysis)."* We agree that heat dissipation and/or absence of reactive waste below 360-380 ft amsl may contribute to a decline in waste temperature below these elevations. However, it is possible that the presence of water/leachate may also have an influence on the temperature of waste below these elevations. The leachate level at LCS-lD, which is located in northern part of the South Quarry has ranged from 390.22 ft to 394.22 ft amsl since July 1, 2014. This corresponds to a liquid height of 138-

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142 ft above the quarry bottom. The impact of the presence of leachate on lateral heat migration should be evaluated and considered.

Response: *Observations made during installation of gas extraction wells and temperature monitoring probes indicate that continuous pore water can occur throughout the entire waste column within the South Quarry portion of the landfill, in part due to evaporation and subsequent condensation of vapor phase moisture. This results in high moisture content within the waste at all elevations, thereby creating heat conductivity and heat capacity profiles with depth that are mainly dependent on increasing density as opposed to a clear transition from a relatively dry to a relatively saturated state at some depth. The depth of occurrence of the temperature profile change referred to is well below the depth where the continuous pore water condition has be observed to exist. The impact of moisture levels within the landfill mass will be included in the modeling through selection of appropriate density, heat capacity and heat conduction values. See response to Comment 5.f for additional information on the modeling status.*

d. A review of the calculations presented in Appendix A suggests that the SSE would result in a temporary increase in radon emissions by 60 pCi $m^{-2}s^{-1}$ (associated with thermal expansion of gases present in the pore space of OU-1 waste) above the estimated existing level of 13.5 pCi $m^{-2}s^{-1}$. Presumably this would result in total radon emissions of 73.5 pCi $m^{-2}s^{-1}$ for a portion of OU-1 (approximately a 75 m^2 area). Although the average emission from OU-1 are estimated to be less than the NESHAP threshold of 20 pCi $m^{-2}s^{-1}$, the potential for and impact of a localized and temporary spike in radon emissions should be further evaluated.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

NESHAPS (40 C.F.R. Part 61) and UMTRCA (40 C.F.R. Part 192) set an average radon release rate of 20 picocuries per square meter per second (pCi/m^2/s) as the standard for the control of residual radioactive materials from inactive uranium processing sites. 40 C.F.R § 192.02 (b)(1) n.2 states: "This average shall apply over the entire surface of the disposal site and over at least a one-year period." The technical approach followed in Appendix A was designed to evaluate routine and non-routine emissions in a manner that allowed a direct comparison with that standard, where possible. While there is no intent to use the site for residential uses, application of this standard allows for a conservative assessment of exposure risk for any potential future receptor.

Overall, based on the size of Area 1 of approximately 40,000 m^2 and an increase in radon flux over an approximately 75 m^2 portion of Area 1, on a weighted average basis, there should be a negligible effect on the overall radon emissions from Area 1. Consequently, the overall radon flux from Area 1 should continue to meet the NESHAP standard.

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The request for a further evaluation is not specific. If the request is to assess human health effects from a sub-chronic exposure to a radon puff, then a first-order screening level calculation can be used to evaluate risks from that exposure. Such a calculation would be semi-quantitative in nature and start by identifying the isolated radon flux and a target receptor. Next, the radon concentration at the receptor's location would be quantified. Because the vast majority of the doses and risks associated with radon come from its decay products (radon progeny), the concentration of radon daughter products that would be created as the emitted radon gas moves from the source to the receptor would be estimated. Concurrently, the assessment would evaluate how the receptor's behavior at the location would result in exposures. Finally, the risk of cancer incidence from the calculated mixture of radon and radon daughter products in the air would be calculated. An example of such a first-order calculation is presented below:

Radon flux- The radon flux presented by the review, 73.5 pCi/m²/s was used in the example calculation.

Receptor description – A person spending 2000 hours per year (h/y) was selected for this evaluation in order to reflect the exposure expectation for a full-time worker.

Receptor location – The location of the receptor was set at the fence along St. Charles Rock Road (~60 meters (m) from the middle of Area 1).

Atmospheric transport – Radon concentration at the hypothetical receptor location was evaluated using the Nearfield Box Model[1] previously described and applied in Section A.I.2 of the approved Baseline Risk Assessment (EMSI 2000):

$$C \approx \frac{Q \cdot F}{H \cdot W \cdot U_m} \approx 0.03 \text{ picocuries per liter (pCi/L) Rn-222}$$

Where:

- C = *Concentration of radon-222 in ambient air (pCi/m³)*
- Q = *Emission rate of radon-222 [5512.5 picocuries per second (pCi/s) = 73.2 pCi/m²/s • 75 square meters (m²)]*
- H = *Mixing height (60 m)[2]*
- W = *Width of crosswind dimension of source area (75 m)*
- U_m = *Average wind speed in open field = 0.22 • U_{10} • ln[2.5 • H] meters per second (m/sec)*
- U_{10} = *Wind speed at 10 m above ground surface (4.35 m/sec, EMSI 2000)*

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[1] *Gas Research Institute, 1988, "Management of Manufactured Gas Plant Sites, Volume III", prepared by Atlantic Environmental Services, Inc.*

[2] *Based on an assumed rise of 1 meter for each 1 meter of horizontal distance traveled, in this case a distance of 60 meters from the center of Area 1 to the boundary of Area 1.*

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F = Fraction of time wind blows toward exposure point (0.1 unitless which is the approximate fraction of time wind blows south to north across Area 1)[3]

Radon daughter ingrowth – Radon gas decays as it ages. When radon-222 (Rn-222, half-life 3.82 days (d)) decays, it produces a series of short-lived radionuclides starting with polonium-218 [Po-218, half-life 3.05 minutes (min)]. Po-218 then decays and produces lead-214 (Pb-214, half-life 26.8 min). This rapid production and decay of successive radionuclides continues with Pb-214 decaying to bismuth-210 (Bi-214, half-life 19.9 min), Bi-214 decaying to polonium-214 [Po-214, half-life 1.63 microseconds (μs)] and Po-214 decaying to the more persistent lead-210 (Pb-210, half-life 22.3 years (y)). For convenience, the portion of the Rn-222 decay series with relatively short half-lives (from Po-218 through Po-214) will be collectively called "prompt radon progeny" or "prompt radon decay products" in this evaluation.

Rn-222 is an inert, noble gas. Prompt radon decay products are created as solid, electrostatically charged particles. When Rn-222 decay occurs below the surface of the ground, these solid, charged particles are drawn to and captured by nearby solid surfaces such as soil particles. Radon gas emitted from the ground surface is thus initially unaccompanied by radon progeny. This is very important because the vast majority of the risk associated with radon exposure is attributable to its progeny, not to the radon gas itself.

Rn-222 continues to decay after it is emitted from the ground to the air above the ground, and this decay produces new radon progeny in the air. The quantity of each radionuclide in this decay series is related to the half-lives of that radionuclide and all preceding radionuclides. This relationship can be expressed in the general form:

$$\frac{dN_i}{dt} = \lambda_{i-1} N_{i-1} - \lambda_i N_i$$

where:

N = the number of atoms of radionuclide "i",
n = the number of isotopes in the decay series, and
λ = the instantaneous fraction of radioactive atoms decaying per unit of time.

Expanding this equation to the specific relationship exhibited by Rn-222, Po-218, Pb-214, and Bi-214 yields:

$$\frac{dN_{Po\text{-}218}}{dt} = \lambda_{Rn\text{-}222} N_{Rn\text{-}222}$$

$$\frac{dN_{Pb\text{-}214}}{dt} = \lambda_{Po\text{-}218} N_{Po\text{-}218} - \lambda_{Pb\text{-}214} N_{Pb\text{-}214}$$

[3] See *Figures 4-1 and 4-2 in the Air Monitoring, Sampling and QA/QC Plan, West Lake Superfund Site Operable Unit 1, Auxier 2014.*

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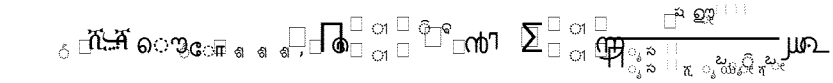
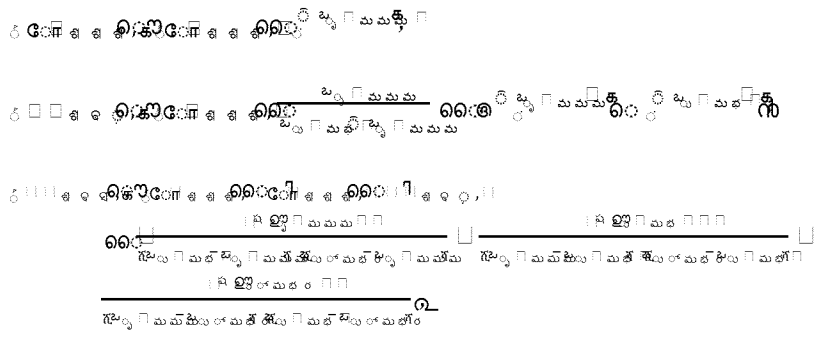
and;

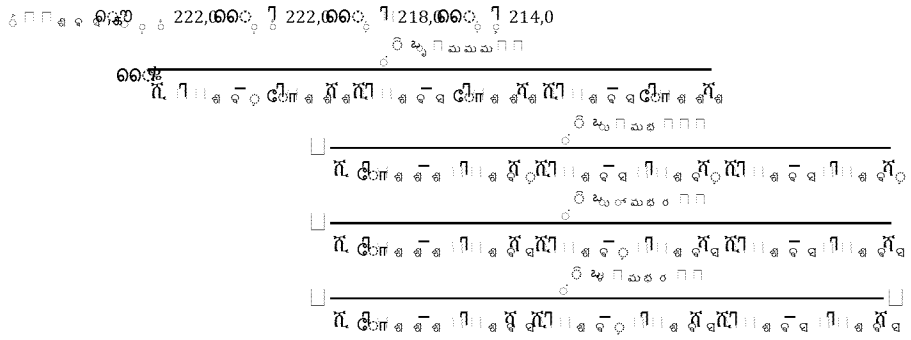
Assuming Rn-222 is the only radionuclide present at t=0, this system of homogeneous linear, first-order differential equations can be solved using standard methods, yielding the following general solution:



Given that the initial quantity of each prompt radon decay product in air is 0 at time 0, the solution to the system of equations describing the decay of Rn-222 gas is:



And;



Produced atoms share the same volume of air as the parent radon-222 atoms, and the activity of each radionuclide "A_i" in that volume at time "t" is the product of its decay rate (λ_i) and the instantaneous number of that radionuclide's atoms in that volume at time "t". Knowing this, the activity of each radionuclide "$A_{i,t}$" can be calculated using the following formula once $N_{i,t}$ has been determined:

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To provide an idea of the amount of radon progeny activity in air as a function of time, the relative ingrowth as a function of time, normalized to the initial concentration of Rn-222, is depicted in Figure 1.

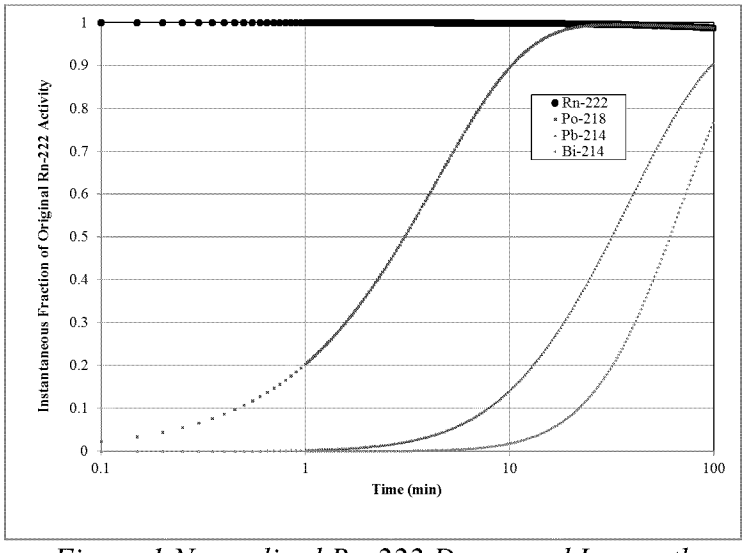

Figure 1 Normalized Rn-222 Decay and Ingrowth as a Function of Time from Rn-222 Release

Average Rn-222 progeny concentrations at the fence line. At a wind speed of 4.35 meters per second (m/s), it will take about 14 seconds (s) for freshly expelled radon gas to reach the fence line. This value has been rounded up to 15 s (0.25 min) for the remainder of this calculation for convenience. During the first 0.25 minute of travel time, some radon-222 atoms will decay, creating atoms of radon progeny. But the relatively short time afforded by movement to the fence line does not allow for much decay and therefore does not allow the concentrations of these progeny to build to more than a few percent of the parent radon-222 concentration. The combined effect of atmospheric transport to the fence and radon decay and radon progeny ingrowth were used to calculate projected air concentrations at the fence line (Table 1).

Table 1 Radionuclide Data and Projected Fence Line Concentrations

Radionuclide	***Initial Concentration (pCi/L)***	***Half-life***	***Decay Coefficient, λ_i (min^{-1})***	***Fraction Present after 0.25 Minutes***	***Average Air Concentration at Fence Line[a] (pCi/L)***
Rn-222	*73.5*	*3.8 days*	*0.00012601*	*≈ 1*	*≈ 0.03*
Po-218	*0*	*3.05 min*	*0.22726137*	*0.055*	*0.0017*
Pb-214	*0*	*26.8 min*	*0.02586370*	*0.00018*	*0.0000054*

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Bi-214+Po-214[b]	*0*	*19.9 min*	*0.03483152*	*0.000017*	*0.00000050*

[a] *Rn-222 concentration calculated using Nearfield Box Model. Radon progeny calculated using instantaneous fractions present after 0.25 minute ingrowth period.*

[b] *Due to its relatively short half-life, Po-214's activity is assumed to be in equilibrium with that of its progenitor, Bi-214 in this evaluation:*

Receptor risk estimate – Using EPA slope factors, an exposure time of 250 d/y, and an inhalation rate of 20 cubic meters per day (m^3/d), a hypothetical receptor at the fence line would inhale 5000 cubic meters (m^3) of air in a year. The incremental cancer risk estimate to such a receptor from radon emitted from the landfill during an SSE was calculated to be:

Radionuclide	***Concentration at Fenceline (pCi/L)***	***Intake @ 5000 m^3/y (pCi)***	***Inhalation Slope Factor (risk/pCi)***	***Immersion Slope Factor (risk·m^3/pCi·y)***	***Risk***
Rn-222	*0.03*	*150*	*3.19×10^{-11}* [a]	*1.62×10^{-12}* [a]	*4.8×10^{-9}*
Po-218	*0.0017*	*8.3*	*0*	*3.95×10^{-17}*	*6.5×10^{-17}*
Pb-214	*0.0000054*	*0.027*	*4.0×10^{-11}*	*1.02×10^{-9}*	*6.6×10^{-12}*
Bi-214+Po-214	*0.00000050*	*0.0025*	*3.1×10^{-11}*	*6.69×10^{-9}*	*3.4×10^{-12}*
				Total Risk→	*$\approx 5 \times 10^{-9}$*

[a] *Because Rn-222 decay produces alpha particles but does not generate appreciable gamma or beta energy, its inhalation and immersion slope factors should then be, in theory, similar to that of Po-218. An inquiry has been submitted to http://epa-prgs.ornl.gov/radionuclides/help/issue.php regarding this apparent anomaly. Initial responses acknowledge the slope factors for Rn-222 and its progeny could be improved, but no progress by EPA is expected in the near future.*

This first order screening calculation implies that risks from this exposure scenario would be well below the 10^{-6} risk level that EPA has designated as the "point of departure" for further investigation at this and other CERCLA sites. Therefore, it is reasonable to assume that the risks at and beyond the fence line should be below the acceptable risk levels established by EPA.

If this response is accepted, the featured calculation will be refined and added to the next revision of the Radon Attachment.

e. The impact assessment of the SSE migrating into OU-1 was limited to the evaluation of the impact due to an increased emission of radon. The presence of RIM in OU-1 may limit the SSE remedial options in the event an SSE migrates into OU-1. Consideration of the potential remedial options and the associated impacts of these options should be taken

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into account for a more comprehensive assessment of impacts of the "No Action Alternative."

Response: *We do not understand this comment. In particular we do not understand what is meant by the phrase "SSE remedial options." Under the No Action Alternative, no remedial actions would be taken relative to possible occurrence of an SSE in Area 1. If the comment is referring to possible future contingent actions in the event that the existing SSE were to migrate toward Area 1 in the future after selection of a No Action Alternative: under the No Action Alternative, monitoring of the extent of the SSE within the South Quarry portion of the landfill and monitoring of temperatures within the North Quarry portion of the landfill would continue to be performed. Such monitoring would provide early warning in the event that the SSE were to somehow migrate to the north towards Area 1. Therefore, implementation of possible contingent measures could be performed prior to a possible occurrence of an SSE in Area 1.*

f. Section 3.0 (Page 5, 2nd Paragraph). Additional information on the thermal modeling described in this section would be helpful to assess the potential of SSE migration into OU-1.

Response: *Evaluation of temperature generation, occurrence, distribution and dissipation within the South Quarry portion of the Bridgeton Landfill is ongoing. In particular, Bridgeton Landfill has implemented a phased heat extraction pilot study – the goals of which are to provide a basis to evaluate heat conduction and heat storage properties of the waste materials, to test hypotheses concerning the heat generation location, and to identify the impact of boundary conditions on the behavior of the heat front movement in the South Quarry neck area. This pilot study was recently expanded in July 2015 to include additional heat removal locations, resulting in a doubling of the heat extraction rate.*

In August 2015 a report titled "Expanded Heat Removal Pilot Study Initial Report" was submitted to the MDNR. This report described the removal of over 1 billion BTUs of heat from the northern portion of the South Quarry and provided information which can be used to estimate heat flux, thermal conductivity, etc. By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.

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g. Section 3.0 (Page 5, 2nd Paragraph). The lack of tracking of material addition (e.g. for grading purposes) in the South Quarry cell and Neck area complicate settlement monitoring. Providing this detail in future settlement monitoring would allow for a more accurate portrayal of site conditions.

Response: *Land settlement surveys of the South Quarry are performed each month with notations of fill that has been added each month; therefore, accurate settlement monitoring is currently being performed. Current tracking of changes in grade generated by materials brought in or removed by the landfill are kept in the form of identification of the specific grid points that received materials. The settlement at those specific locations are not obtained for the specific monitoring period but are estimated based on the nearest grid point neighbors. This has not and does not preclude tracking of settlement trends in the areas and identifying the progress of settlement and active settlement zones.*

h. Section 3.4 (Page 6, 2nd Paragraph) (and other points throughout the document)it is stated that "No Action" alternative does not pose any potential for odor emission. We suggest that this be clarified since odor emissions have occurred and been well-documented at the site for more than a year. The "No Action" alternative would likely result in similar odors that are currently emanating from the South Quarry if the SSE were to migrate into the North Quarry and beyond and should be discussed.

Response: *The intent of the statement was not to imply that there may not be odors in the unlikely event that the South Quarry SSE were to migrate to the North Quarry. Instead, the statement was intended to indicate that the No Action Alternative would pose no additional potential for odor emissions from construction activities because there would be no construction activities associated with this alternative.*

i. Section 3.6.1 (Page 7, 1st Paragraph) states that "Monitoring of waste and landfill gas temperatures, landfill gas quality (e.g. carbon monoxide and hydrogen), and surface settlement all indicate that the SSE occurs only in the Bridgeton South Quarry area ..." To our knowledge, no routine surveying has been conducted in the Bridgeton North Quarry cell as has been conducted in the South Quarry and Neck area, so it is not clear how a statement can be made that a lack of settlement in the North Quarry cell is evidence that no SSE is occurring there.

Response:

Settlement monitoring extends a limited distance into the North Quarry, beyond the TMP-1 to TMP-4 line. No settlements indicative of any reaction have been noted in this area since monitoring began in December 2012. Monitoring of gas well composition and temperature has been ongoing in the North Quarry since the implementation of NSPS

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regulations in 1996.. No indication of reaction or elevation of temperature has been observed during this period.

TMPs 16 through 29 were installed in the North Quarry in August 2014 and January 2015 and have been monitored since their installation. No temperatures indicative of any reaction activity have been observed.

No settlements of a character not consistent with normal landfill behavior have been observed and comparisons of topographic maps do not indicate any settlement areas that are inconsistent with this conclusion.

j. Section 3.6.1 (Page 8, 1st Paragraph). Including a review of the referenced Phase 1 Investigation of potential IB alignments would be helpful in comparing the stated conditions in this report to those described in the referenced report.

Response: *The Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report (Feezor Engineering, Inc. 2014) was submitted to EPA on December 19, 2014 and contains the requested information.*

k. Section 3.6.1 (Page 8, 1st Paragraph). Information presented in this paragraph suggests that the extent of RIM has been defined, but past sampling did not identify a complete delineation of RIM. Additionally, the discussion in the report indicates that a limited amount of RIM is expected to be present in the southwest border between the Bridgeton North Quarry and OU-1. The dimensions and justification for this statement would be helpful, as it appears unusual that a very small amount of RIM would be present given that the barium sulfate material was used as a routine operational daily cover at the OU-1 cell.

Response: *The statement is based on the results of the Phase 1 investigation. The Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report was submitted to EPA on December 19, 2014 and contains the requested information. The conclusion regarding the limited amount of RIM in the southwestern portion of Area 1 was based on the results of the Phase 1 investigation which indicated an overall lower thickness and general lack of continuity of RIM in the southern and western portions of Area 1 as compared to the thicker and more continuous deposits in the northern and eastern portions of Area 1. Additional investigations (i.e., the Phase 1D investigation and Additional Characterization of Areas 1 and 2) are being performed to define the nature and extent of RIM in the southwestern and western portions of Area 1, and the results of these investigations will be reported when they become available.*

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l. Section 3.6.2 (Page 10, 2nd bullet of 2nd paragraph) states an increase in the emission of radon as a result of an increase in gas permeability from soil moisture vaporization. The increase in gas permeability would also increase the advective radon flux. The radon emission estimate presented in Attachment A is based on RAECOM, which appears to only estimate the diffusive flux of radon. The impact resulting from an increase in the advective radon flux should also be estimated.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Advective (bulk) movement of soil gas requires a driving force (i.e., a pressure differential) to displace the interstitial gas. Without such a driving force, the hypothetical changes in soil would not, in themselves, change the advective component of radon movement. Attachment A presents various postulated phenomena that could create a pressure differential between the subsurface gas and the overlying atmosphere (e.g., displacement of soil gas due to subsidence and compaction of the waste as discussed in Section 2.4.2 of Attachment A). An evaluation of potential advective transport associated with such phenomena is included as part of the calculated combined radon flux in the event that an SSE were to occur in Area 1. The results of these evaluations are presented in Section 2.6 of Attachment A.

Specific Comments:

6. One of the core concerns in regards to the concentrations of radionuclides at the site relates to the fact that the wastes accepted at the landfill contained an elevated ratio of Th-230 to uranium and radium. The uranium ore processing residues were the result of a process that was designed to separate out uranium and radium thereby leaving thorium in the residue (Sections 2.0 and 5.4.2 of the 2008 ROD). Th-230 is the parent radionuclide for Ra-226. Th-230 was found on the surface in Area 1 at a maximum concentration of 57,000 pico Curies per gram (pCi/g), while the maximum surface concentration for Ra-226 was 910 pCi/g (Table 5-2 of the 2008 Record of Decision [ROD]). The 95% upper confidence limit (UCL) for Th-230 of the arithmetic mean on the surface was 8,140 pCi/g, while the 95% UCL of the arithmetic mean for Ra-226 on the surface was 581 pCi/g (Table 7-1 of the 2008 ROD). The 95% UCL for Th-230 of the arithmetic mean at all depths was 1,060 pCi/g, while the 95% UCL of the arithmetic mean for Ra-226 at all depths was 71.6 pCi/g (Table 7-1 of the 2008 ROD).

In naturally occurring material Ra-226 and Th-230 will be in secular equilibrium with each other. However, the sampling results combined with the materials history indicate that Ra-226 and Th-230 are not in secular equilibrium at Area 1. Due to the relatively "short" half-life of Ra-226 (1,600 years) when compared with the much longer half-life of Th-230 (75,000 years), Ra-226 will effectively reach equilibrium with Th-230 in about

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10,000 years. Because of this, it is important that when assessing the future risk and dose at the landfill the future concentration of Ra-226 should be considered and discussed.

The ingrowth of Ra-226 from the decay of Th-230 was identified as a concern in Section 7.2.2 of the 2000 Remedial Investigation (RI), and a sample calculation is provided for the Ra-226 concentration in Area 2 after 1,000 years. Going from the 189 pCi/g value for the 95% UCL for the arithmetic mean for Area 2, to 871 pCi/g after 1,000 years. Additionally, in Table 7-4 of the ROD the future 95% UCL concentration for Ra-226 in the surface soil and all depths for Area 1 at 1,000 years are shown to be 3,224 pCi/g and 417 pCi/g respectively. Furthermore, Table 2 of the 2011 Supplemental Feasibility study (FS) shows a summary of the Th-230 decay and Ra-226 ingrowth for Area 2. As can be seen on this table, the peak Ra-226 concentration occurs at around 10,000 years. This is further demonstrated in Figure 15 of the FS. In Appendix F of the Supplemental FS, the cover thickness calculations are verified by use of the same RAECOM web calculator referenced in Attachment A of the Isolation Barrier Alternatives Analysis document. Appendix F of the Supplemental FS uses the Ra-226 concentration at 1,000 years for the 95% UCL of all the data for Area 1 (which can also be found in in Table 7-4 of the ROD) when providing the input for the RAECOM calculator. One could argue that since the Ra-226 concentration will peak and be closer to the current Th-230 concentration in 10,000 years, the 10,000 year concentration should be used. However, radiological risk assessments are generally carried out to 1,000 years.

In all of the scenarios provided in Attachment A of the Isolation Barrier Alternatives Analysis document, the 95% UCL of the arithmetic mean for Ra-226 at all depths of 71.6 pCi/g for Area 1 (from the 2000 RI) was used without consideration of the ingrowth of Ra-226 due to the decay of Th-230. While it may be useful to consider current conditions, future concentrations of Ra-226 due to the decay of Th-230 should be taken into consideration.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The time frames associated with a possible SSE occurrence in Area 1 and increases in radium activity due to ingrowth from thorium decay are substantially different. The disequilibrium between the thorium and radium activity levels will result in an increase in radium levels over time. Calculations previously performed as part of the Supplemental Feasibility Study (SFS) indicated that peak (highest) radium levels will not occur for approximately 9,000 years (see Table 2 and Figure 15 in the December 2011 SFS report). Although for some purposes it might be appropriate to consider the future radium levels due to ingrowth of radium, this is not necessarily the case for evaluation of an SSE. While the radium levels may increase over time, the potential for an SSE will simultaneously decrease over time owing to microbial decomposition of the organic fraction of the waste materials. Inspection of the core samples obtained during the Phase 1 investigation of Area 1 indicates that over the 40 years since the waste was placed in

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Area 1, much of the waste material has already decomposed, resulting in a mixture of waste, decomposed waste, and soil. Continued decomposition of the waste materials is expected in the future. Continued decomposition of the waste materials reduces the amount of, and combustibility of, remaining materials, thereby reducing the potential for an SSE to migrate into or occur within Area 1. Thus, although the radium levels may increase over the next 9,000 years, the waste materials in Area 1 will simultaneously continue to decompose, thereby reducing the potential for an SSE to occur in Area 1. It is therefore appropriate to evaluate the potential impacts of an SSE under the current conditions.

Further, as discussed in Attachment A, the radon flux from an area impacted by an SSE would have to exceed 1,560 pCi/m^2/s in order to result in an overall radon emission from the surface of Area 1 at a level that would exceed the UMTRCA limit of 20 pCi/m^2/s. An average radium-226 concentration of 1,872 Ci/g would be required to generate a radon flux of 1,560 pCi/m^2/s (See Section 2.7.1 of Attachment A). The maximum radium-226 activity level found in Area 1 was 906 pCi/g. Calculations included in the SFS indicated that the magnitude of radium-226 increases attributable to decay of thorium-230 would be approximately 13% over a period of 30 years and 44% over a period of 100 years (see Table 2 and Figure 15 in the SFS). Over the next 30 to 100 years, ongoing decomposition of the waste material will continue to decrease the combustibility of the waste such that it is unlikely that 75- or 145-year-old waste would even be able to support pyrolysis. Therefore, the levels of radium within the Area 1 landfill, even accounting for potential increases due to ingrowth from thorium, will still be less than the levels necessary to cause the radon emissions to exceed the NESHAP/UMTRCA standard over the next 30 to 100 years. These calculations are extremely conservative because they assume that no engineered landfill cover or other remedial action that would act to attenuate the radon emissions will have been implemented during this period. Evaluations of the required landfill cover thickness contained in Appendix F of the SFS report demonstrate that installation of an engineered landfill cover will greatly reduce radon emissions.

7. RIM was identified within 6 inches of the surface of Area 1 during the RI. The most elevated sample was identified on the surface. While the area identified with RIM present on the surface is smaller than that of the subsurface, any overburden thickness would be difficult to assess and in some portions of the site it is known to be zero. Attachment A assumes that an overburden exists across the site at 30 centimeters when performing the RAECOM calculations. However, when performing the calculations for the ROD selected remedy in Attachment A there is no overburden barrier assumed between the RIM and the remedy layers. The calculations for the cover thickness in Appendix F of the Supplemental FS do not calculate baseline conditions but rather mimic the ROD selected remedy calculation in Attachment A. In Appendix F of the Supplemental FS there is no assumed overburden between the RIM and the remedy. Calculation of the 95% UCL at all depths appears to include the surface sample results

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and is the basis of the RAECOM calculations. Section 2.2.2 of the 2011 Supplemental FS states the following:

"Radionuclides are present in surface soil (0-6 inches in depth) over approximately 50,700 square feet (1.16 acres) of Area 1. Approximately 194,000 square feet (4.45 acres) of Area 1 have radionuclides present in the subsurface at depths ranging up to 7 feet, with localized intervals present to depths of 15 feet."

Please provide an explanation as to why an overburden soil was assumed to be present for the baseline scenario and why it was assumed to be 30 centimeters.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

RIM is present at the surface only in approximately 10% of the overall area of Area 1. RIM in the remainder of the site is covered with up to 7 meters of fill. The 30 cm overburden used in the model was chosen as a nominal cover depth across the entire disposal unit. It is less than the area-weighted-average depth of overburden in Area 1 and will overestimate the average radon flux in the area. Therefore, although this approach assumes the presence of some cover material over that portion of Area 1 where RIM is present at the surface and therefore underestimates emissions from approximately 10% of the area, overall it is a conservative evaluation because it assumes a thinner cover thickness over the majority of the RIM in Area 1 and therefore likely overestimates the overall emissions rate from Area 1. It should be noted that under the ROD selected remedy, a new engineered landfill cover would be installed over Areas 1 and 2 and, consequently, there would not be any RIM exposed at the ground surface.

8. In section 2.2 of Attachment A the calculated radon flux from the current configuration of Area 1 is compared to the average measured value during the 2000 RI. It should be noted that while the average Radon Flux sample resulted in 13 picocuries per meter squared per second (pCi/m2/s), 24 samples were collected and the three highest values were 245.9 pCi/m2/s, 22.3 pCi/m2/s and one was 8 pCi/m2/s. The remainder were all below 1.9 pCi/m2/s. The mode of the data is 0.2 pCi/m2/s and the median is 0.4 pCi/m2/s. With the 245.9 pCi/m2/s value removed the average becomes 2 pCi/m2/s. Therefore the 13 pCi/m2/s average of the measured data does not compare well with the remainder of the measured data and warrants clarification.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The NESHAP and UMTRCA standards apply to the average flux from a waste disposal unit. We agree that the average of the measured values likely represents an over-estimate of the actual flux from Area 1. Therefore, the evaluation presented in

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Attachment A is conservative and likely overestimates the magnitude of a potential increase in radon emissions if an SSE were to extend into or otherwise occur in Area 1.

9. Ra-226 is a naturally occurring isotope found in varying concentrations throughout the world. The background soil concentrations determined in the RI are around 1 pCi/g. The RAECOM calculations in Appendix F of the FS assumed that each remedy layer would consist of material that contained 1 pCi/g. Background concentrations of Ra-226 in soil can easily range between 0.5 and 3 pCi/g. It would be difficult to find soils that don't contain Ra-226. However, the RAECOM calculations included in Attachment A all assume the overburden, as well as the remedy layers, contain 0 pCi/g. Please provide an explanation for assuming the overburden and remedy layers contain no Ra-226 activity.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The intent was to calculate the net radon flux as a result of the presence of the RIM. The model will be revised to include background concentrations of Ra-226 in the overburden material. The estimated impact on radon emissions under current conditions is less than 1 pCi/m^2/s. Installation of the ROD-selected remedy could result in additional radon arising from background concentrations of Ra-226 in the earth materials used to construct a landfill cover. However, this effect is expected to be minimal when combined with the overall reduction in radon emissions that would occur as a result of increased thickness and lower permeability of the engineered landfill cover. Given the minimal emissions through the ROD-selected remedy cover, the impact of any additional radon emissions from the cover materials therefore should be negligible in terms of overall radon emissions from Area 1.

10. In the Isolation Barrier Alternatives Analysis document, one of the disadvantages of some of the more intrusive alternatives is testing for thorium, requiring a 24-hour sample turnaround period. Depending on how plans are developed, standard Ra-226 analysis for soil has a 21- day turnaround (due to the in-growth of Bi-214) that could further complicate these alternatives and merits acknowledgement.

Response: *We agree that laboratory analyses are required to determine the presence of thorium and that laboratory analyses for Ra-226 require substantial time; actual times are on the order of 45 days rather than 21 days. The time required for radium analyses will be included in any future schedules that may be developed.*

11. Another consideration for alternatives that require excavation into the RIM is that radiologically-impacted fugitive dust has the possibility of being generated and additional

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controls to mitigate this would need to be implemented. This would have an impact on cost, schedule and provide a potential risk to site workers and merits acknowledgement.

Response: *We agree that excavation of RIM could potentially result in generation of radiologically-impacted fugitive dust. Evaluation of the potential for fugitive dust emissions, associated possible risks to workers and the public, the potential need for mitigation, possible mitigation measures, the costs associated with such mitigation, and the potential impacts of mitigation on the construction schedules will be conducted, as necessary and appropriate, during any future evaluations or design phase activities.*

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U.S. Army Corps of Engineers (USACE) Comments transmitted to USEPA December 3, 2014

One of the Alternatives evaluated in the October 2014 Isolation Barrier Alternatives Analysis report submitted by Bridgeton Landfill LLC is a heat extraction barrier. However, the Alternatives Analysis report lacked detailed information necessary for USACE to make an independent technical evaluation of the potential effectiveness of such a system. It is understood that Bridgeton Landfill, LLC is proposing to expand on the current test well and perform a pilot study to obtain information to demonstrate the effectiveness of this proposed alternative and to obtain data necessary for design of the system.

Additional Data Required for Evaluation:

The information identified below is information USACE will need regarding the preliminary heat extraction study at GIW-4 and information on the next phase of the study consisting of retrofitting 6 additional GIW wells with recirculation coolant tubes, to assess whether adequate information is being collected to design an effective heat extraction system.

- Schematic of the modified GIW-4 used in the preliminary heat extraction study including depth and construction of the well and all pipe sizes where fluid is flowing.

Response:

Attached are the details of the GIW-4 initial extraction device (see Attachment A). The system was cooled using pond water for the duration of the trial. A calculation sheet and graph of the heat extraction rate is provided (see Attachment B). Starting in late October 2014, GIW-4 and other GIW wells were retrofitted with different designed exchange elements. The details of this work, and the results were summarized in the Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015. A copy of this report is provided (see Attachment C).

- Details of the cooling equipment and/or coolant being used in the pilot study.

Response:

The requested information is contained in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015 (see Attachment C to these responses to comments). The details of the subsequent expansion of the GIW heat removal work is also attached (see Attachment C). The specifications for the cooler used

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in the study are contained in Attachment D. We have also provided the MSDS for the glycol used in the pilot study, as well cooler specifications from the manufacturer (see Attachment E).

- The preliminary data collected from the heat extraction study at GIW-4 including inflow and outflow water temperatures, flow rate, and the temperature within the casing measured at multiple depths.

Response:

As discussed in previous responses on this topic the initial demonstration for GIW-4 was expanded significantly. The data and calculation for GIW-4 is attached (see Attachment A). In addition, the data obtained from the expanded project that began in October of 2014 and is still ongoing are included in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015 (see Attachment C).

- Calculations to determine the 25kW extraction rate.

Response:

The calculation is provided. It was calculated using the product of the mass flow, the temperature difference between the incoming and outgoing water temperature at the extraction point head end and the approximate heat capacity of the water at constant pressure (see Attachment B).

- Location of the 6 additional GIW wells to be retrofitted with recirculation coolant tubes including depth and construction of the wells and all pipe sizes where fluid will flow.

Response: *This information is contained in the above mentioned "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015.*

- An explanation of how the modified GIW wells are representative of the proposed driven heat extraction wells and whether or not a pilot study of driven wells of the material proposed for the full scale system will be tested prior to design and installation of the system.

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Response:

At present, insertion techniques for shallow holes will likely utilize driven installation techniques, while installation of deeper elements may include the use of bored holes. Bridgeton Landfill has extensive experience with the bored hole technique, should it be required for installation purposes. Modeling will use the actual proposed physical configuration of the cooling point to assure that the heat removal capacity—relative to point spacing—is adequate.

- Plans of the proposed closed loop header system used to convey cooling water to the mechanical cooler.

Response:

The loop header will be similar to that currently being used in the South Quarry pilot study (details provided in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015). A final design for a full-scale, permanent heat extraction system may differ in some details. The most significant design feature is the use of insulated conveyance piping of sufficient diameter to supply the inflow and return flow. The inflow and warm liquid return are actually different piping systems with a throttled connection at the end of the cooled liquid loop to maintain circulation rates.

- Location of current Temperature Monitoring Probes and depths and proposed locations and depths of temperature measurements when the pilot study is expanded.

Response:

This is included in the report to the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015.

- Proposed study procedures including assumptions used.

Response:

A description of the operating procedures are contained in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015. There were no assumptions utilized of any major significance in the calculation of heat removal. The rates presented in the studies were instantaneous rates at the time the readings were taken. The minor assumptions were that the temperature at the inlet to a given exchange unit was reasonably estimated by averaging the temperature reading on the supply

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header before and after the exchange unit location. It was also assumed that, given the small range in the temperature and pressure within the system, the heat capacity of water could be considered a constant value.

- Proposed calculations to determine thermal conductivity and heat storage properties of the landfill waste. In addition, how is obtaining thermal conductivity and heat storage properties of the South/North Bridgeton landfill waste representative of these properties in the proposed location of the heat extraction system in the West Lake Landfill waste?

Response:

It was initially envisioned that a thermal modeling exercise would be conducted after the heat removal pilot study. However, during the heat removal pilot study, it was decided to expand the cooling loop system to include 5 more GIWs (GIW-8, GIW-9, GIW-11, GIW-12 and GIW-13). Since the pilot study expansion, Bridgeton Landfill has committed to providing a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis. This technical evaluation, including modeling and design will be submitted to the MDNR by November 1, 2015 and will be provided to EPA.

- Results of the assessment of heat front progress to the north and the rate of energy flux to the north.

Response:

See response to the previous comment. The modeling will provide input parameters including heat flux assessments.

- Calculations used to predict the amount of heat that could be extracted under steady state conditions and the results of those calculations.

Response: *See response to the previous two comments.*

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- A plan view of the proposed Temperature Monitoring Points as well as a cross section showing depth intervals of temperature readings. Attachment C indicates it is envisioned as one array per 120 feet would be sufficient. Is this 120 ft spacing parallel with the proposed barrier?

Response:

The array depicted in Attachment C is preliminary in nature. It is premature to suggest what the array would be at this time. This will be determined with the full scale barrier design. The conceptual array included in Attachment C was oriented parallel to the potential barrier alignment.

- 14) It appears the settling front associated with the SSE would render the heat exchange system non-functional if the system fell with the influence of settlement (similar to the need to set back Option 3 IB wall). Therefore, it appears the heat exchange system would need to halt the SSE and settling front some distance south of the barrier to prevent this failure from occurring. What distance is this and what temperature needs to be attained some distance from the barrier to prevent this from happening?

Response:

We do not agree with this observation. The facility is currently removing heat successfully in an area that has undergone significant settlement. The proper selection of piping elements allows the deformations associated with settlement to be tolerated. This issue would be addressed in the final design phase.

The final design may include the option of adding extraction elements in locations south of a temperature compliance line so as to improve total extracted energy. Since it would be entirely improbable that a heat front would approach any compliance line as a unified front at the same time, it is unrealistic to suggest that a complete heat removal system for the entire length of a compliance boundary is required in advance of the heat front being within some agreed upon trigger distance from the boundary.

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U.S. Army Corps of Engineers (USACE) Comments transmitted to USEPA November 6, 2014

1) Section 3.4. If no action option is implemented and the SSE moved through the north quarry into Area 1, it is likely that the surface of the north quarry would drop and any leachate collection lines could potentially be severed due to the drop in landfill surface. If that occurred, would leachate spills from severed lines cause a potential increase in odors?

Response: *Leachate collection lines are on the surface and would not be severed by a gradual drop in the landfill surface. Landfill maintenance personnel would monitor any landfill settlement to prevent problems with leachate collection lines.*

2) Section 3.6. At what depth to surface is there a risk of an SSE igniting a surface fire? If the SSE is able to migrate vertically it seems that there may be a potential for an SSE to ignite surface material.

Response: *The SSE and the associated elevated heat front in the South Quarry has not extended up to the surface, possibly reflecting the fact that the rate of heat dissipation from the ground surface is greater than the rate of heat transmission to the ground surface resulting in the ground surface acting as a heat sink. Therefore, there are no data on what depth below the surface an SSE at the site could pose a potential risk of ignition of surface vegetation. Furthermore, the potential for ignition of the surficial vegetation in Area 1 by an SSE is a function not only of the depth to a possible SSE, but the actual subsurface/near surface temperatures and the soil and vegetation moisture contents. On another note, Bridgeton Landfill, in conjunction with the local first responders, has developed an incident management plan relative to potential responses to possible surface fires. Bridgeton Landfill has also participated in tabletop exercises developed by the St. Louis County Office of Emergency Management to evaluate potential responses and agency coordination relative to possible emergency situations, including a possible surface fire. Therefore, if a surface fire were to occur for whatever reason, a response action plan identifying predetermined response actions and communications procedures has already been developed and evaluated.*

3) Section 3.6. Last sentence- recommend including a reference to the section of the report where the quantitative evaluation for the No Action Alternative is included.

Response: *The primary impact of an SSE relative to RIM occurrences is the potential for a temporary increase in radon exhalation. The potential increase in radon emissions if an SSE were to occur in Area 1 are evaluated in Appendix A.*

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4) Section 3.6.1. Descriptions of locations of heat generating material are provided in Paragraph 3; however, it is difficult to follow the description. Recommend including a figure to help show/clarify the information trying to be conveyed.

Response: *By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis. This report will provide a description of the modeled heat-generating zone along with the information used to make that assignment.*

5) Section 3.6.1. Para 5, 4th sentence. Inclusion of boring log cross sections with nearby temperature probe data on a figure would help clarify this information and prevent the reader from having to dig through past reports submitted to EPA and reports submitted to MDNR to confirm the information presented. Additionally, current boring logs from the most recent sampling event where additional RIM was found would be beneficial as well.

Response: *There are no temperature monitoring probes located near any of the Phase 1 investigation boring log cross sections, and as such, the data cannot be superimposed. However, measurements obtained from the closest temperature monitoring data points in the North Quarry area (TMPs 16 -18 and TMPs 21-29) are indicative of a normal methanogenic conditions.*

The most recent sampling data, including all of the Phase 1 GCPT soundings and soil boring logs, were submitted to the USEPA in the Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report on December 19, 2014.

6) Section 3.6.1. Last paragraph -overall claim that it is highly unlikely that the SSE could migrate laterally- recommend that all the data cited to support this claim be provided with this report and clearly identified.

Response: *The basis for the conclusion that lateral migration of the SSE in the South Quarry to Area 1 is highly unlikely was provided in the preceding paragraphs of Section 3.6.1 and include the following:*

- *The extensive monitoring of the volume and quality of landfill gas produced by the North and South Quarry areas of the Bridgeton Landfill, the temperature of*

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the waste materials and landfill gas, and monitoring of settlement of the surface of the South Quarry area of the Bridgeton Landfill, all of which are reported to MDNR on a weekly, monthly and quarterly basis;

- *Tracking of the extent of settlement of the surface of the South Quarry area which indicated that the direction of movement of the SSE has been to the southeast away from the North Quarry area;*

- *The rate of movement of occurrences of elevated temperatures toward the neck from the south has slowed to just a few feet per month and appears to be related to conduction of heat from the warmer portions of the South Quarry, as opposed to occurrence of an SSE and locally generated heat in the neck area. This is evident in some of the temperature profiles adjacent to heat extraction points contained in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015 (see TMP 5-*N and TMP 10-*N, versus their S counterparts). The report described in the response to Comment 4 will provide analyses on this issue.*

- *Multiple air sampling events since 2012 support the proposition that the SSE is moving away from the Neck, North Quarry and Area 1. Levels of constituents of concern found gas samples in the "Neck" area of the landfill between the Landfill's North and South Quarries were significantly less than levels detected in this area in samplings in 2012/2013. A June 2015 air sampling study (Bridgeton Landfill Ambient Air and Landfill Source Gas Sampling-January 2015, Stantec, June, 12, 2015) submitted to MDNR (summarizing data from January 2015) noted that "[t]he concentrations and specific groups of constituents of concern in source gas from the Neck resemble source gas from the North Quarry where the subsurface reaction is not occurring."*

- *Monitoring of waste and landfill gas temperature, landfill gas quality and surface settlement, which all indicate that the SSE only occurs in the South Quarry area;*

- *Evaluation of the depth intervals of increased temperature occurrence and potential thermal gradients, mechanisms associated with heat retention within/near the heat generating materials and heat conduction and dissipation away from these materials to assess potential naturally occurring heat removal mechanisms (e.g., heat sinks associated with the quarry's bedrock walls and bottom and heat dissipation through the landfill surface);*

- *The stepped nature of the bottom of the North Quarry area (i.e., the step-ups in the elevation of the quarry bottom that result in the decrease in the overall thickness of waste moving to the east and north) and the decreasing width of the quarry area to the north and east which result in an increased proximity of the*

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heat dissipation effects of the non-waste materials (alluvium and bedrock) below and adjacent to the northern and eastern portions of the North Quarry area; and

- *Current evidence of the impact of thinner waste and the proximity of non-heat generating, but higher-heat-conducting materials can be seen in the temperature with depth records of TMP-16 through 29, all in the north quarry.*

7) Section 3.6.1. Para 4, last sentence -Approximately how many other sites indicate no pyrolysis occurs in waste depths of less than 60 feet? Refer to section 4.7, advantages bullet 4 which states alignment 1 offers the lowest potential for a SSE to original on the north side of the barrier because the alignment is located along the northern boundary of the North Quarry area. Recommend consideration that the bullet language be changed to state that it offers the lowest potential for a SSE due to the alignment and the thickness of waste being less than 60 feet.

Response:

Installation of landfill gas wells within the hotter areas of the South Quarry have indicated that pyrolized waste has been encountered as shallow as 40 feet, but not above that depth. However, it is believed that an SSE would not occur in a waste column with a total thickness of less than 100 feet, nor has such been observed. As an example, the Countywide Landfill has experienced a large SSE. The SSE occurred entirely in a section of landfill that was approximately 210 feet deep while an adjacent section that was about 100 feet deep was not affected by the SSE. Unlike at Bridgeton Landfill, there was no "neck" present to provide containment of the SSE; waste thickness alone seemed to be the reason that the SSE did not move into the adjacent 100 foot-thick area. Additional detail on the Countywide Landfill can be provided at USACE's request.

8) Section 3.6.1, 3rd Paragraph. The 10th line states that materials below the 360 to 380 elevation are undergoing heat loss. Para states that 360 to 380 may be the depth of reactive wastes or may reflect "thermal restraints". Has the elevation of the groundwater level in this part of the quarry been considered? Is it such that the groundwater level is serving as a "thermal restraint"?

Response: *Relative to a thermal barrier positioned south of the "neck", the report described in the response to Comment 4 will provide analyses on this issue.*

9) Section 3.6.1 3rd Paragraph. The final sentence in this paragraph states that a similar pattern of heat dissipation is seen as the elevation in the landfill approaches the ground surface. The on-going studies/data that support this assertion and others made

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within this report should be included in this report as an attachment so the assertions can be easily verified without having to search through multiple reports to find supporting data.

Response:

These data are presented in the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015. In addition the temperature profiles are routinely reported to MDNR. In addition, the report described in response to Comment 4 will provide additional detail.

10) Section 3.6.1, 4th Paragraph. This paragraph builds on the assertions of the previous paragraph stating that significant reduction of waste thickness in the north section of the north quarry will increase heat dissipation and expressed doubt that any significant pyrolysis would occur in wastes of such a shallow thickness. The paragraph asserts that this is consistent with observed behaviors of other sites with waste thickness less than 60-feet. Please provide references of the cited landfill SSEs to facilitate review of the referenced performance.

Response:

See response to comment 7 within this series relative to the 60 foot discussion. The idea is that even if heat is generated per unit of landfill mass at the same rate as it is in the South Quarry, at the present time, the overall reduced thickness of the waste in Area 1 and the consequent closer proximity of the heat sink boundaries(i.e., ground surface and underlying bedrock), will result in much lower temperatures within the waste, relative to those experienced in the South Quarry. This is not something that has occurred at other sites (since these conditions have not existed at other sites) but cannot be dismissed given the nature of heat flow. Pyrolysis of waste has not observed in waste materials above 40 foot in depth in the South Quarry where the dissipating boundary at depth is more than 200 feet below. Therefore, it is reasonable to conclude that when a non-heat generating surface is only 50 to 70 feet below the ground surface that no waste will pyrolyze, especially given that the underlying rock/alluvium is a much better heat exchange surface than the air/landfill surface interface.

11) Section 3.6.1, Pg 7, 3rd Paragraph. How is the 25 times greater heat dissipation in Area 1 over that of the South Quarry determined?

Response: *Given that heat dissipation is proportional to the square of the length of distance from a cool (heat sink) boundary, the five-fold reduction in the height of the waste column from approximately 250 ft in the South Quarry area to approximately 50 ft*

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in Area 1will result in a 25 fold increase in heat dissipation for area 1 compared to the South Quarry area for the same temperature distribution.

12) Section 3.6.1, Pg 7, 3rd Paragraph. The statement that "no pyrolysis in waste depths of less than 60- feet should be supported by literature and/or example sites.

Response: *See the previous statement of observation of 40 feet at this site presented in response to comment 7.*

13) Section 3.6.1, Pg 8, 1st Paragraph. It would be helpful to provide a figure (cross section) illustrating what is being described in this paragraph.

Response: *Upon completion of the Phase 1D investigation, a figure demonstrating the relationship between the RIM occurrences, the underlying alluvium/bedrock and the overlying North Quarry waste can be prepared and included in the comprehensive Phase 1 report.*

14) Section 3.6.1, Page 7. Typo in second paragraph"... indicating they these materials..."

Response: *Comment noted. The text should have stated "...indicating* ***that*** *these materials..."*

15) Section 3.6.2. It would assist in evaluation to provide updated figures defining the perimeter of Area 1. Figure 4-14 from the RI shows the locations where flux sampling was conducted. Locations 105, 107, 110, 120, 121, 122, 123 and 124 appear to be outside of the defined Area 1 boundary and their use in determining average flux activity may bias the actual flux from Area 1 low, though Location 105 does appear to have elevated Ra-226.

Response: *A figure showing the extent of the Area 1 waste deposits was recently prepared and was included in the work plan addendum for the Phase 1D investigation. Future figures depicting Area 1 will include the extent of the Area 1 waste deposits. Upon completion of the Phase 1D and the Additional Area 1 and 2 investigations a preliminary estimate of the revised extent of RIM in Area 1 will be prepared.*

Please note that all of the RI Area 1 radon flux measurements were obtained from within Area 1; however, it is possible that some of them were obtained outside of the RI defined extent of RIM in Area 1. As noted above, the extent of RIM will be re-evaluated based on the results of the Phase 1, Phase 1D and the additional Area 1 and 2 investigations, the

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results of which may indicate that even some of the RI radon flux measurement locations that are within Area 1 but may have been outside of the previously defined extent of RIM may actually have been obtained from within the extent of RIM in Area 1 (as revised).

Regardless, the NESHAP and UMTRCA standards for radon emissions are for an average rate from the entire waste management unit (please see 40 CFR §192.02 (b)(1), and in particular associated footnote number two, which states "This average shall apply over the entire surface of the disposal site and over at least a one year period). Therefore, determination of the average flux should be based on the average of all of the Area 1 flux measurements or, possibly more appropriately, an average of measurements obtained from the entire site or at a minimum a combined average of the flux measurements from Areas 1 and 2.

16) Section 3.6.2. Is Subpart T (Disposal of Uranium Mill Tailings) the cited NESHAP requirement? St. Louis FUSRAP has evaluated radon releases against the 40 CFR 192.02 (b) alternate criteria of 0.5 pCi/L, which may be also be an appropriate criteria to evaluate if UMTRCA is an ARAR. This would be better criteria to evaluate what exposure there may be to members of the public, if any. Models such as CAP88, AERMOD, or RESRAD-Offsite may be helpful to demonstrate a lack of current exposure, or monitoring data taken downwind from the facility could be discussed.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The 0.5 pCi/L criterion applies to locations outside of a disposal site (please see 40 C.F.R. § 192.02 (b)(2)). This is not an absolute value but instead a limit on the incremental increase allowed outside of the disposal site. This criterion may have been used for the St. Louis FUSRAP sites because these sites were not considered to be disposal sites. In contrast, the West Lake Landfill is a disposal site, and therefore the criteria used at the St. Louis FUSRAP sites are not the appropriate criteria for the West Lake Landfill. Consequently, the NESHAP criteria for disposal sites are considered to be the relevant and appropriate requirement.

17) Section 3.6.2. It may be helpful to note here that additional radon generation may also be present in effluent releases from the gas collection system and not solely through radon emanation from the surface as discussed in Section 4.4 of Appendix A.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

We agree that radon may be present in the effluent releases of any gas collection system, but we believe that this is unrelated to the content of Section 3.6.2, "Potential Impacts if

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a SSE were to occur in Area 1," because there is no landfill gas collection system in Area 1.

18) Section 3.6.2. Bullets- there were a total of 7 conclusions in EMSI's report. 5 of those conclusions appear to relate to potential impacts if an SSE were to occur of the SSE that, at a minimum, should be addressed as part of a no action consideration. This report addresses only 3 of the 5 bullets. Recommend including and addressing bullet 4 from EMSI's report: "An SSE in West Lake Area 1 or 2 would create no long-term additional risks to people or the environment." and bullet 5 from EMSI's report: "Any short-term risks would be associated with the temporary increase in radon gas coming from the surface of the landfill if no cap is installed on the landfill, or if the cap called for by the 2008 ROD was not properly maintained."

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The revised report will include an appendix with calculations of potential short-term (worker and public) and long-term risks that may arise from an SSE occurring in Area 1. In order to perform such calculations, Auxier & Associates requests EPA concurrence on calculation of site-specific, aggregate slope factors for radon and its progeny using time-dependent radon-progeny equilibrium factors. The text in Section 3.6.2 will be revised to include all five bullets.

19) Section 3.6.2. Para 4. the Flux calculations in Attachment A are compared with surface radiation measurements from the EMSI RI report in 2000. Recommend including that surface measurements will be taken to confirm calculated concentrations prior to selection of any no-action approach.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The prior RI measurements already demonstrate that Area 1 meets the NESHAP/UMTRCA standard for a disposal site. After implementation of the ROD selected remedy, an additional set of radon flux measurements are expected to be obtained to demonstrate the effectiveness of the new engineered landfill cover. Given that the RI measurements previously demonstrated that Area 1 already meets the NESHAP/UMTRCA standard for radon emission from a disposal site, it is logical to conclude that once an engineered landfill cover is placed over Area 1 it will reduce the already compliant radon emissions to an even lower level. We will include text in Section 3.6.2 stating that confirmatory measurements will be taken as part of implementation of the ROD selected remedy as required by NESHAPS.

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20) Section 2.6.2. Para 6. States that "even if these conditions were to occur, the radon emission rate from Area 1 could still be less than the standard…." then in the last sentence of the paragraph states the magnitude of radon emissions would still be less than the establishes standard…." The use of these two words seems contradictory.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The "could" in the first sentence of the paragraph will be revised to "would" so both sentences are consistent.

21) Section 3.6.2, p 9, 3rd Paragraph. The discussion regarding leachate generation rates is appears inconsistent with the June e 2013 Contingency Plan which states, "Heating of waste which results in steam/water vapor front moving out, up, and away from the SSE, which then condenses in the cooler surrounding waste mass and gas extraction well resulting in higher localized leachate generation." Please clarify.

Response:

*As stated in the contingency plan, one of the impacts of the SSE is higher **localized** leachate **generation** <emphasis added>. Occurrence of higher leachate generation in localized areas of the South Quarry does not indicate that the overall amount of leachate generated in the South Quarry has increased; rather, that the **volume** of leachate collected has increased. We have no method to measure the actual volumes of leachate being generated, only the volumes of leachate being extracted from the landfill. Leachate extraction rates have varied in response to a number of factors including, but not limited to, antecedent leachate extraction rates; groundwater inflow rates; refurbishment/replacement of leachate extraction sumps and pumps; installation and operation of additional leachate extraction points, landfill gas condensate traps, dual-phase extraction wells; changes in landfill gas extraction locations and extraction rates; and limitations imposed by available leachate storage, treatment and discharge capacity limitations; among other factors. Bridgeton Landfill has experienced a change in the locations of leachate collection – specifically, more leachate is being collected from shallower leachate extraction points, landfill gas extraction wells and dual phase extraction wells as a result of the SSE. However, there are no data to indicate that the overall amount of leachate being generated by the facility has increased. The field capacity of the waste material has undoubtedly decreased as a result of pyrolysis of the waste and resultant consolidation/compaction which has resulted in release of "free liquid" leachate that was previously contained with the waste mass.*

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22) Section 3.7, Pg 12, 4th bullet. This bullet appears redundant. Recommend removing.

Response: *It is not clear as to what this bullet is redundant with. It was included because one of the criteria set forth by the USACE for evaluation of the IB alternatives was the duration of construction activities. Given that no action would be taken under this alternative, there would be no construction activities under the no action alternative.*

23) Section 3.7. A no action alternative would still require additional monitoring to observe whether modeled radon flux corresponds to actual radon flux in the event an SSE migrates to/occurs in Area 1.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Collection of radon flux measurements from Area 1 in the event that an SSE were to migrate into or otherwise occur in Area 1 can be added to the No Action Alternative, although it is our opinion that such measurements would be unnecessary. The radon flux from Area 1 already meets the NESHAP/UMTRCA standard without any engineered landfill cover. Installation of an engineered landfill cover over Area 1 will serve to significantly reduce the already compliant radon emissions from this area. The standards of 40 C.F.R. § 192.02, and in particular footnote 1,[4] do not require post-capping monitoring to demonstrate compliance with the standards. Regardless, the description of the No Action Alternative will be modified to include possible collection of radon flux measurements from Area 1 in the event that an SSE were to ever occur in this area in the future, subject to a future determination by EPA that such measurements were necessary.

24) Attachment 1, section 2.2. The RI states that the 95% UCL of the mean for surface radium is 581 pCi/g. Because shallow/surface material will contribute more to radon flux than subsurface material, it seems like an additional surface layer should be added to the RAECOM model.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

As discussed above, RIM is present at the surface only in approximately 10% of the overall area of Area 1. RIM in the remainder of the site is covered with up to 7 meters of

[4] *Footnote 1 of § 192.02 states: "Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) [the longevity criterion] and (b) [the radon emission criteria]."*

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fill. In addition, radium-226 concentrations in all but one of the Area 1 surface soil samples (WL-106) were reported to be less than 581 pCi/g. It would not be reasonable or representative of Area 1 to add a surface layer across the entirety of Area 1 that contains 581 pCi/g of radium. It should also be noted that under the ROD -Selected Remedy, a new engineered landfill cover would be installed over Areas 1 and 2 and, consequently, there would not be any RIM exposed at the ground surface.

25) Attachment 1, section 2.2. Though the reviewer agrees that the average flux calculated over Area 1 is 13 pCi/m^2/s and below the 20 pCi/m^2/s standard, Area 1 seems very heterogeneous, with only 1 measurement the same order of magnitude as 13 (location WL-106 at 22.3). Most flux measurements are well below this, but measurements exist ranging from 0 to as high as 246 pCi/m^2/s. Given that sample data and flux data is available for most locations it may be helpful to run the model for each location where surface flux and surface/subsurface sample data is available to determine how well the RAECOM model compares to actual site data.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The table below presents the measured radium-226 concentration and the measured and modeled radon flux values for select measurement locations. The concentration values reflect radium-226 in the first foot of soil. The parameters used to calculate the radon flux were exactly those used for the baseline conditions, but with no 30 cm overburden; that is, they are based on an assumed thickness of radium bearing material of 1.4 m; a radon emanation fraction of 0.2; a porosity of 0.671; and diffusion coefficient of 1.95E-6.

Location	*Radium-226 (pCi/g)*	*Measured Rn-222 Flux (pCi/m2/s)*	*Calculated Rn-222 Flux (pCi/m2/s)*
WL-106	*906.00*	*22.30*	*291.9*
WL-111	*0.91*	*0.30*	*0.293*
WL-112	*1.32*	*1.90*	*0.425*
WL-114	*109.00*	*8.00*	*35.12*
WL-116	*0.94*	*0.20*	*0.303*

The calculated radon flux for each sample location is either comparable to or greater than the measured radon flux at each location, indicating that the model likely overestimates the radon emissions. This likely results from the use of generic site values for the model (e.g., standard layer thickness for the radon generating material, etc.) rather than values specific to each.

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26) Attachment l, section 2.2. It would be helpful to justify the use of 0.2 as the radon emanation fraction, as the RAECOM online instructions recommend a value between 0.2 - 0.3 and 0.2 is the low end of this value. The RESRAD default value is 0.25, which may be more appropriate.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

A radon emanation coefficient of 0.2 is an appropriate, representative estimate of this parameter in soil. The use of 0.25 as opposed to 0.20 minimally increases the radon flux at the surface. For example, for the ROD selected remedy scenario, the radon flux at the surface increased from 5.7 to 7.1 pCi/m^{2}s. The radon emanation coefficient for mill tailings is 0.17; therefore, a value of 0.2 will tend to over-predict radon emanation from mill tailings. We will add the source article for this emanation coefficient value to the reference list of the report.

27) Attachment 1, section 2.2. This analysis seems to imply an SSE is impacting the top l.7 m of soil. At what point would risk transition from increased radon release from subsurface soil to release from a surface fire? If an SSE encounters material in the top 6' of soil it seems like ignition of surface material may pose a larger risk than increased radon production. A surface fire could potentially pose greater risk than a SSE (i.e. dust kicked up with Th or U).

Response: *It is assumed that under the Isolation Barrier No Action Alternative, an engineered landfill cover consistent with that described in the ROD-selected remedy would be installed over Area 1. The engineered landfill cover would be constructed from natural earthen materials (e.g., rock, clay, and soil) which do not burn and therefore will not ignite. The surface of the landfill would have a vegetative cover consisting of grass that could be subject to a surface fire; however, such grass would be isolated from the underlying waste materials (RIM or non-RIM) by 1.7 m of non-combustible earthen materials.*

28) Attachment 1, section 2.2. Is the cited gas temperature increase to 80° C consistent with current observations of the SSE and assumptions used for the design and evaluation of alternatives? Discussion above (Section 6.1) seems to suggest 200°F (~90° C) is a design consideration?

Response:

The stated value of 200° F is proposed as a very conservative design performance limit for concrete. This temperature was chosen as a value up to which there would be no concern about any concrete performance issues. The temperatures within the concrete

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would be maintained at or below this limit. The 175° F (80° C) is what is proposed as a compliance temperature for heat extraction limits to limit issues on the north of barrier. If heat extraction were to be installed on the hot side of the barrier to eliminate settlement issues, the target temperature limit would be 200° F.

29) Attachment 1, section 2.2. Area l should be better defined on a drawing (similar to Figure 4-14 of the RI) to ensure that "clean" flux measurements are not inadvertently included, see comment #16.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Additional work has been performed to better define the extent of the Area 1 waste disposal unit, and the revised boundary will be included on all future figures (for example see the figure of proposed boring locations for the Phase 1D investigation). Please also see the prior response to Comment No. 16 related to the application of the NESHAP and UMTRCA radon standard to waste disposal units.

30) Attachment 1, section 4.5. Though a comparison to 10 CFR 20 may be helpful in the absence of other regulatory criteria, it should be noted that 10 CFR 20 effluent releases generally apply only to releases from an NRC licensee and may not be applicable at a CERCLA site. The effluent concentrations listed in Table 2 correspond to a public total dose of 50 millirem/year, which is above those generally allowed by EPA at CERCLA Sites. Recommend you don't compare to 10 CFR 20 since EHA has a more stringent standard.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

We will revise this section to remove the reference to 10 C.F.R. Part 20 limits and compare current measured radon emissions from stack gas to incremental emissions. We will not compare the stack gas emissions to any standard or criteria since we cannot differentiate the calculated RIM derived additional radon effluent of 5.74 x10-11 µCi/mL from typical background radon levels that are collected and vented by the landfill gas collection system (in the range of 1 x 10-7 µCi/mL to 1 x 10-6 µCi/mL in soil gas and 1 x 10-9 µCi/mL to 1 x 10-8 µCi/mL in flare influent).

31) Attachment l, section 4.5. Suggest removal of the last paragraph of Section 4.5 as the release of radon into the air from stack release is not directly comparable to radon present in soil gas.

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Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The text relating to soil gas was included to show the extreme variability of radon concentrations across Region 7. The modeled stack release is then compared to the intake stream of the Bridgeton Landfill Flare #2 gas flare stack, which is directly comparable.

32) Attachment 1, section 4.5. 10 CFR 20 Appendix B Table 2 contains two values for radon, one for radon in 100% equilibrium and one for radon without daughters. Suggest a clarification that radon effluent releases are being compared to the 0.1 pCi/L criteria that assumes all daughters are present in equilibrium, or provide a discussion of measured/assumed equilibrium factor.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Per the response to comment 30, this section will be revised and will no longer include the comparison to 10 C.F.R. Part 20 limits. Since we are not comparing the gas stack effluent to 10 CFR 20, the comparison to Appendix B Table 2 is also removed.

33) Section 4.0. The analyses of Options 1 and 3 generally agree with the analyses completed by USACE and provided to the EPA in the "Isolation Barrier Alignment Alternatives Assessment" dated 25 August 2014.

Response: *Comment noted.*

34) Sections 4.0 and 6.0. The eastern limits of the Option 1 & 3 alignments shown on Drawing 002 appear to violate the location of the North Quarry wall shown on Figure 2 of Part I of the Bridgeton Landfill Contingency Plan. Please verify that the proposed alignment does not violate the quarry wall and indeed meets the assumed 45-degree offset.

Response: *The location of the high wall associated with the North Quarry was identified based on historical aerial photographs as part of preparation of the Work Plan Addendum for the Phase 1D investigation. The location of the high wall will be added to future drawings as appropriate. Based on the figure in the Phase 1D Work Plan Addendum, the eastern limit of the alignment of Options 1 and 3 does come close to but does not extend over the eastern limit of the North Quarry high wall. Because the above-ground refuse in the eastern part of the North Quarry area of the Bridgeton Landfill is much less thick than refuse column in the western portion of the North Quarry area, the*

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amount of setback required for the 45 degree offset is less in this area; however, the location of the barrier alignment and the offset area will be checked against the location of the high wall.

In addition, the North Quarry's geometry is such that there are two steps to the lower quarry floor elevation. Along the east, the first ledge is approximately 80-90 feet below the ground surface. The 45 degree offset was a design rule of thumb to avoid deeper fills over 150 feet. The eastern alignment avoids the deeper fills by over a 45 degree offset.

35) Sections 4.2 and 6.2. The excavation volumes are based on a 60-foot wide working platform which will be wide enough to accommodate the slurry trench excavating machinery and tooling. But the typical section of the slurry trench cutoff wall shown in Dwg 16 locates the wall at the center of the 60-foot wide platform. The plan view of Alignment l with the Waste Cut areas shown on Dwg 003 clearly shows the alignment assumed to be at the centerline of the work platform. But to accommodate the excavating machinery, the excavated trench will need to be much nearer one of the edges of the work platform. Given that the alignment is fixed based on occurrence and non-occurrence of RIM in the foundations, and the alignment must be near the edge of the working platform, the excavation plan must be shifted laterally up to 20-feet. Similar issue with Alignment 3.

Response: *Comment noted. The excavated trench can be placed nearer to the edge of the working platform.*

36) Section 4.2, Pg 13, 1st Paragraph. A construction platform of 45-ft was originally discussed. A comment was made on the Pre-construction work plan, section 2.1 that asked you to ensure that the proposed 45-ft wide excavation is enough to allow access for support vehicles. Is the additional 15 feet required for support vehicles? If so, please clarify what this width accommodates and how the equipment will be configured such that 60' is required.

Response: *The 60 foot wide excavation platform is wide enough to allow access for support vehicles. The 60 foot width allows 45 feet for trenching and support equipment and 15 feet for support vehicles. This was confirmed with two potential contractors. While a wider platform was desired by one, another thought 45 feet would be adequate. Therefore we indicated the pre-excavation width to be 60 feet, as an average. Since this width directly drives the waste relocation volume, this width needs to be minimized to the extent possible while still providing adequate access to the construction area.*

37) Section 4.2, Pg 13, 1st Paragraph. Based on a review of the cross sections and a comparison to Option 3 (where there is substantial change of elevation along the length

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of the wall), it appears that a working platform could be constructed for Option 1 with much lower pre-excavation volumes. This would result in a slightly deeper wall but may be a good tradeoff due to odor and bird mitigation issues.

Response: *The goal of the barrier height is to keep it close to 40 feet which allows more options in terms of the materials being used. In addition, the pre-excavation serves as a drainage corridor, which will allow the drainage to be diverted away from St. Charles Rock Road.*

38) Section 4.2, Page 14, top Paragraph. This indicates the barrier volume is 5,000 bcy, however sheet 003 indicates the barrier volume is 7,500 bcy.

Response: *Comment noted. Option 1 barrier volume is 5,000 bcy.*

39) Sections 4.3 and 6.3. The l0th line states that trench construction "using slurry would require slurry decanting/liquid". Slurry trench construction requires large volumes of slurry (typically soil- bentonite slurry) to provide trench wall support during trench excavation. When completed this slurry is typically processed to remove as much of the soil solids that are suspended in order to reduce the volume of slurry liquids that must be properly disposed of. A 10-foot wide, 3-foot thick, and 40-foot deep panel will need 1,200 cu-ft (8,970 gallons) of slurry. In this case, if a particular trench panel encounters RIM during its excavation, how will the slurry be disposed of? How you intend to address the slurry should be included in Section 4.1 or 4.2 (and 6.1 or 6.2) as it is waste that will be required to be disposed.

Response:

It is anticipated that once the recoverable solids have been removed, the remaining liquid/slurry that was not reusable will be solidified on site. Further evaluation of potential management and disposal options for any slurry that may come in contact with RIM, or for any other RIM related materials that may be encountered during construction, can be evaluated as necessary and appropriate during the design phase. As discussed in the responses to other comments we believe that consolidation of any RIM material that may be encountered during construction in Area 1 is the best solution in terms of engineering feasibility and implementability, potential risks to workers and the public, short-term impacts, costs, and schedule along with the need for additional fill to achieve grades in Area 1. However, we understand that EPA, in conjunction with any decision document for an isolation barrier, will ultimately decide between on-site consolidation and off-site disposal of any RIM that may be encountered during installation of an isolation barrier. Please also see the response provide later in this document to MDNR's comment relative to relocation of RIM in Area 1.

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40) Sections 4.3 and 6.3. USACE has studied the 3-dimensional global stability of earthen levees assuming discrete panels excavated near the levee toe. This analysis is completed using FLAC-3D. Depending on the geotechnical parameters of the various fills/wastes encountered in the trench and remaining in the adjacent excavated slopes, longer panels may be safely used thereby shortening the construction times. To complete this analysis, detailed geotechnical exploration incorporating in- situ measurements of shear modulus with pressure meter must be completed. Recognize that this is a design issue to be addressed later; however, it can impact the quoted schedule.

Response: *We acknowledge that use of Flac-3d may be appropriate. Longer panels could be considered. It is agreed that such items would be addressed later in the design process. Because the scope of the additional investigations that may be needed to support design are unknown at this time, the potential impact to schedule cannot be determined at this time; however, it is possible that the additional investigations could potentially impact the design schedule.*

41) Section 4.3, Pg 14, lst Paragraph. Recommend changing "reaction" to "SSE".

Response: *As explained in the introductory paragraph to these comment responses, the SSR occurring in the South Quarry is in fact a chemical reaction that involves pyrolysis, although we agree that use of the term "reaction" in this particular paragraph may be unclear. We therefore agree that the SSE abbreviation for the subsurface smoldering event can be used in place of "reaction" in this section.*

42) Section 4.3, Pg 14, 1st Paragraph. Recommend expanding on the limitation associated with storm water management.

Response:

Factors potentially causing difficulties for management of stormwater during barrier construction could include:

- *No available area for construction/operation of a stormwater pond, so stormwater would have to be retained and managed with smaller temporary catchments;*

- *Stormwater in contact with waste during waste relocation would have to be collected and managed as leachate and at present all available capacity of the on-site leachate treatment plant is being used for other purposes;*

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- *Unknown requirements for ultimate discharge to MSD;*

- *Presumed sampling and analysis of the water before its discharge can be determined, and associated delays with that process; and*

- *Slurry operation during rain events would require care to prevent runoff being mixed with slurry. This would require use of special containment pans into which the slurry mix could be pumped.*

43) Section 4.3, Pg 14, 1st Paragraph. The design timeframe (103 wks) has increased substantially over what had been previously discussed. Based on a review of the schedule there appears that there are places where durations could be reduced. For example, investigations could begin prior to completion of the heat extraction study.

Response: *The proposed schedule can be reviewed to determine if there are areas where time frames can be reduced. However, it is important that all the work on this project be completed with full knowledge of factors that could affect the design and operation of each phase of the project, such that any false economy relative to projected construction schedules does not occur.*

44) Section 4.3. Last Paragraph. EPA will have to make determination on requirement regarding the need to test waste above the 1975 topographic surface. This is a landfill and although there may not be RIM above the 1975 topographic surface, there may be other constituents of concern and testing may be warranted.

Response: *The North Quarry portion of the Bridgeton Landfill was permitted for, operated as, and continues to be operated as a municipal solid waste landfill and therefore only municipal solid waste (MSW) has been disposed in this unit. In addition, the placement of MSW in the upper portion of the North Quarry unit (i.e., the North Quarry MSW that now overlies the southern portion of Area 1) occurred in 2002 (see for example Google Earth aerial photograph dated March 2002 as compared to the aerial photograph from November 2002 which clearly demonstrate that the placement of the North Quarry MSW over the southern portion of Area occurred in 2002). Placement of MSW in 2002 occurred long after the promulgation and implementation of the Resource Conservation and Recovery Act (RCRA) and its associated regulations that prohibit placement of hazardous wastes in MSW landfills. Therefore, there is no need to sample the overlying MSW. In the event that excavation is performed for construction of an Isolation Barrier, protocols will be developed to visually inspect the waste to identify any materials that may require special handling or disposal methods including, but not limited to, drums, containers of liquids, or asbestos-containing materials.*

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45) Section 4.6. Recommend that laboratory data and boring logs from last sampling event be provided along with an updated dwg of currently know extent of contamination and information regarding vertical distribution of contamination if the information is to be relied upon for this report to back up a no action response. Recommend including a dwg showing estimated 1975 topographic surface and 1975 aerial photographs upon which this estimated surface is based. Would need to include that information that is being relied upon in this report to support the no action option.

Response: *The requested materials were included in the Phase I GCPT Isolation Barrier Investigation Report that was provided to EPA on December 19, 2014.*

46) Section 4.6. Para 2 –recommend the specific section in Attachment A that contains the info being referenced in this text be added within the parentheses so it is easy for reader to locate the information.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

We will add a reference to Attachment A, Section 4 through Section 4.6.

47) Section 4.7, Pg 17, 6th bullet. Although there is a caveat later in the document regarding acceptability of leaving excavated RIM waste on-site, that is far from certain so recommend not listing it as an advantage.

Response: *The 6th bullet on page 17 (overall the 7th bullet in the list) says "With the exception of any RIM that may be encountered, the volume of which is expected to be relatively small and could potentially be relocated into Area 1…". We believe that subject to the selection of a final remedy for OU-1 and evaluation of the actual amount of RIM that may need to be removed in conjunction with potential implementation of an isolation barrier, consolidation of such RIM in Area 1 should not be eliminated. Regardless, waste that does not contain RIM will be relocated into Area 1. The smaller amount of waste relocation (non RIM) for Option 1 is an advantage since it can be placed entirely in Area 1 without any horizontal placement against the North Quarry landfill.*

48) Section 4.7. It would be helpful in evaluating alternatives if an estimate of the potential amount of RIM to be excavated was discussed.

Response: *As discussed under the response to EPA comment no. 4, a preliminary revised estimate of the extent of RIM in Area 1 will developed based on the results of the*

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Phase 1D investigation and will be presented in the report of the results of the Phase 1D investigation and/or the comprehensive Phase 1 report. The final determination of the extent of RIM will be performed as part an update to the "complete rad removal" alternatives based on the results of the prior NRC an RI investigations and the results of the Phase 1 and Phase 1D investigations and upcoming Additional Characterization of Areas 1 and 2. The preliminary evaluation of the extent of RIM to be presented in the Phase 1D or Comprehensive Phase 1 report or the final determination of the extent of RIM to be presented in the Supplemental SFS report can be used to estimate the amount of RIM that may be encountered during construction of each of the potential IB alternatives and the amount of RIM that may need to be relocated during possible installation of each IB alternative.

49) Section 4.7. The extent of RIM has not yet been determined. Recommend author considers qualifying the language in the first paragraph by indicating that the statements are based upon data collected to date and that the extent of RIM has not yet been determined.

Response: *Although the exact extent of RIM has not been finally determined, the occurrences of RIM within the southwestern portion of Area 1, where an isolation barrier may potentially be located, were generally very thin and relatively discontinuous and thus the volume of RIM that should be encountered if an isolation barrier were to be constructed in this area is expected to be relatively small. Regardless, per the prior comments and responses, an estimate of the amount of RIM that may be encountered and the amount that may need to be relocated under each alternative can be developed based on the preliminary evaluation of the extent of RIM to be presented in the Phase 1D and/or Comprehensive Phase 1 report or the final determination of the extent of RIM to be presented in the Supplemental SFS report.*

50) Section 4.7. Report states, "Radon emissions from the RIM material located outside of the barrier would not result in an exceedance of the Radon NESHAP." Because the extent of RIM has not yet been identified and because of the heterogeneity of the waste placement, recommend that this text be revised to allow for this consideration.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

As discussed above, based on the RI sampling, radon emissions from Area 1 meet the radon NESHAP and UMTRCA standard. Therefore, regardless of the extent of possible RIM occurrences in the southern portion of Area 1, the overall radon emissions from Area 1 are not expected to exceed these standards. Further, the greatest thickness and shallowest occurrences of RIM, the least amount of overburden material, and highest radionuclide activity levels identified in Area 1 – and thus the materials with the greatest

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contribution to the overall radon emissions – are located in the northern and northeastern portions of this area, not in the southern portion of Area 1. The thickness and continuity of the RIM occurrences in the southern portion of Area 1 were by comparison substantially smaller, and this material occurs at substantially greater depths with substantially more non-RIM overburden than the materials located in the northern portion of Area 1. We agree that the exact limit of the occurrences of RIM containing radium and/or thorium above the unrestricted use standards has not been precisely defined relative to potential alignments for a possible thermal isolation barrier at this time. However, given that the Area 1 radon emissions already comply with the NESHAP/ UMTRCA standards, combined with overall low thickness and relatively discontinuous nature of the occurrences of RIM in the southern portion of Area 1, as well as the presence of a substantial amount of non-RIM overburden material in this area, any radon emissions that may occur from RIM located on the south side of a potential isolation barrier are not expected to result in an exceedance of the radon standard.

Setting aside these considerations, investigations of possible RIM occurrences in the western and southwestern portions of Area 1 are ongoing, and based on the priorities EPA has currently established for the site work, the results of these investigations should be available prior to preparation of a revised Isolation Barrier Alternatives Assessment and can therefore be accounted for as appropriate.

51) Section 4.7. Disadvantages – can non-rad waste removed as a result of barrier installation be placed back in the landfill? If this has not yet been determined, then it is recommended that it be captured as a disadvantage because there is a possibility that it would not be approved. If not approved, it would significantly impact the construction duration.

Response: *Pursuant to the Administrative Settlement Agreement and Order on Consent for Removal Action – Isolation Barrier between EPA and Bridgeton landfill, LLC and Rock Road Industries, Inc. (CERCLA-0702914-0002), EPA required Bridgeton Landfill to evaluate potential areas for onsite relocation of MSW that may be excavated as part of construction of an isolation barrier. A report of potential locations for possible waste relocation was prepared and submitted to EPA on July 31, 2014. It is correct to suggest that moving non RIM waste off site would increase the construction time estimate. However, when Bridgeton Landfill, LLC agreed to investigate and consider an isolation barrier as an option, on-site relocation of non-RIM materials was a condition of agreement.*

52) Attachment B, para 1.1.2. Another opportunity to provide clarity to the design would be to assume that the "maintenance" of the wall would include re-adjustment of the top of fill elevation on the "hot-side" of the wall. As the pyrolysis induced settlement (accelerated settlement due to consumption of waste materials due to SSE) occurs, the

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ground surface on the "hot side" of the wall could be raised to limit the difference in ground surface between the "hot side" and "cold side" of the wall. Use of careful compaction techniques (from just spreading fill to fully compacting the fill) could keep the in-place unit weight of the fill to within acceptable levels to equalize the geostatic horizontal stress placed on both sides of the wall.

Response: *We agree that placement of additional (inert) fill over areas that experience settlement is one option that could be used to mitigate potential for lateral stresses within and deflection of a physical barrier near the ground surface. However, placement of additional fill on the surface may not limit potential for deformation of the wall in the deeper portions of the subsurface.*

53) Attachment B, para 1.1.2. The first paragraph states that it has been determined that anchoring the NCE into the alluvium/bedrock is not feasible. Dwg 004 shows the Option 1 NCE proposed to extend down to elevations 420 to 430. Cross section AA in Figure 2 of Part I of the Bridgeton Landfill Contingency Plan shows bottom of wastes or top of bedrock at/around elevation 425 under OU-1 Area 1. It seems that the top of rock may be quite close and if so, anchoring the NCE into the bedrock may not be as infeasible as first thought. Use of hydro mill technology to key into the bedrock is a common technique. Keying into bedrock will provide clarity on the fixity of the bottom of the NCE.

Response:

We agree that in some areas the top of rock is near to the bottom of waste. However, since the intent of the barrier is to limit the migration of a heat related event (SSE) which relies on the presence of waste and the build up of temperature, it is not clear what advantage anchoring the NCE into bedrock would achieve. If it were to be carried into the rock sufficiently to create a cantilevered section it may generate some structural advantage in areas where the waste height is shallow. Conversely, such a cantilevered section would greatly increase the structural requirements of the NCE to support the moments that would be generated and could require anchors that would extend into the waste to the north of the barrier alignment or possibly even through the waste into the underlying bedrock. Installation of such anchors would likely increase both the amount of waste excavation and the overall time required for installation of such a barrier. RIM would also likely be encountered during installation of such anchors.

We would agree in future documents to identify this anchorage as feasible. At the present time we are not of the opinion that it offers any significant advantage to the NCE system. It would clearly increase the time of installation and the time during which panels would be required to remain open prior to concrete placement.

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54) Attachment B, para 1.1.2. Perhaps the responsible party should consider a limited application of the heat extraction technology installed on the "hot-side" of the wall. If successful, it could limit the temperature applied to the concrete surface and thereby limit the heat induced stresses/strains.

Response:

Bridgeton Landfill would consider the use of a heat removal only barrier, such as the alternative presented which relies on the removal of heat energy and limits temperatures in the waste. Such a system would be best deployed in the areas where elevated temperatures were anticipated to occur, with sufficient time to install and begin operations prior to the arrival of such elevated temperatures. Installation of such a system too far in advance of when it is needed is considered inappropriate because some of the components of such a system could become non-functional or obsolete over time.

Implementation of heat extraction in conjunction with an NCE would be redundant given that the heat extraction component would limit or likely eliminate the need for an NCE. Implementation of a heat extraction system just prior to any occurrence of elevated temperatures in the area of potential concern would further eliminate the need to place considerable infrastructure in the ground, where it will begin to deteriorate at some rate, likely years before it is needed and likely in areas it will never be required to be operated. This would be akin to placing dewatering wells in service years in advance of thinking dewatering would be required for areas that ultimately may not need to be dewatered.

Consideration of adding heat removal south of the NCE to all NCE options to control settlement could be included in future evaluations. The evaluations of this option should include the need to provide access to such points and the impacts this will likely have on the width of excavations needed for the barrier.

It is the opinion of Bridgeton Landfill that no NCE is required in the event that heat removal to this level is performed. Specifically, if the heat extraction option can be shown to be effective to reduce temperatures within the fill, why would a physical barrier need to be installed?

55) Attachment B, para 1.1.3. See comment #42 concerning 3 dimensional slope stability using FLAC-3D.

Response: *Comment noted. Please see the prior response to comment no. 40.*

56) Attachment B, para 1.1.3. A monitoring system will also include surveys of the ground surface adjacent to both sides of the wall. Also, replaceable temperature gages

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should be installed in the wall interior. Given the proposed life span of the wall, the temperature gages would have to be accessible for maintenance and replacement as necessary. Also some kind of telltale extending to the base of the wall to determine its elevation (if not embedded into bedrock) should be considered. It is recognize this is a design consideration and would be addressed during design.

Response: *Comment noted. We concur that this would be part of the final design.*

57) Section 6.2, Pg 22, 1st Paragraph. Recommend explaining why a barrier width of 5.0-ft was assumed versus the 3.0-ft width of Option 1. It is assumed this is for structural considerations due to the greater depth of the wall.

Response: *The comment is correct. The wider thickness was included for structural considerations associated with the greater depth of the wall under Option 3.*

58) Section 6.2, Pg 22, 1st Paragraph. Sheet 010 indicates a barrier volume of 7,500 bcy for Option 3 as opposed to the 11,000 bcy sited here in the text.

Response: *Comment noted; the volume of the barrier for a 5 foot width is 11,000 bcy.*

59) Section 6.7, Pg 25, 2nd bullet. Recommend not listing the potential to leave excavated RIM waste on-site as an advantage.

Response:

*The text indicates that "**With the exception of any RIM that may be encountered,** the volume that may be encountered is expected to be relatively small and therefore could **potentially** be relocated into Area 1, all of the waste materials excavated under this alternative would be relocated on-site." We believe the above statement is factually correct and does not require any revision. Please also see the response to prior comment no. 47 above and to MDNR's comment regarding RIM relocation in Area 1 provided later in this document.*

60) Section 6.7. The extent of RIM has not yet been determined. Recommend author considers qualifying the language in the first paragraph by indicating that the statements are based upon data collected to date and that the extent of RIM has not yet been determined.

Response: *Please see the response to Comment No. 49 provided above.*

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61) Section 7. It is stated that for Option 4, the heat extraction points would be installed such that depths of the extraction points would be relatively shallow. Does this shallow installation still include installation down to the bedrock as indicated in drawing sheet 16'?

Response:

It is not believed to be necessary to extend heat removal devices into bedrock, unless a design feature is to remove heat from the materials underlying the waste. However, it may be desirable to do so. This would be determined at the time of design. Therefore, Drawing Sheet 16 has been revised to indicate that the heat removal features may not extend all the way to bedrock. The actual depth of any heat removal feature will be determined during the design phase.

62) Section 7.1. It is stated for Option 4, that the cooler would consist of an adiabatic air cooler installed with a closed loop liquid circulation system. While Attachment C., Heat Extraction Barrier Design Memorandum, describes a close circuit cooling tower. Please verify that a close circuit cooling tower is the current design concept.

Response:

The cooler is a closed circuit cooler with external spray to allow cooling to near the dew point. The specifications for the cooler are presented in Attachment D. The cooling unit will be similar to the one currently being used in the Heat Removal Pilot Study. See the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015 for details.

63) Section 7.1. The limiting criteria for any barrier system would be to maintain the waste on the north side of the barrier at an average temperature of 175 degrees Fahrenheit. What is the best guess for the entering and leaving temperatures of the cooling liquid at this time?

Response:

The temperatures entering the cooling points will vary – typically tracking the wet bulb temperature, with a maximum daily temperature averaging around 85 degrees F – (during summer) temperatures leaving should be no greater than 15 degrees F higher than incoming. The information submitted to the MDNR in the August 2015 report showed the range of temperatures for incoming flow and outgoing flow. The annual average temperature is expected to be close to 50 deg F using coolers similar to that currently being utilized.

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64) Section 7.1. The heat extraction points would be driven in place vs. drilling a well. What is the typical depth that the pipe can be driven into place? What is the depth of the bedrock at the proposed locations? What is the possibility of success with this method of installation?

Response:

At the present time we are evaluating driving versus drilling. Some advantages are offered by either method (driven points offer speed of installation, drilled points are a proven method. The final chosen technique(s) will be required to allow exchange elements to be advanced to the depth required. Bridgeton would perform field trials for insertion techniques other than drilling if they are selected.

65) Section 7.6. Para 2. Potential RIM outside the barrier is not expected to pose a significant risk (see attachment A) and RIM outside barrier would not result in exceedance of Radon NESHAP. Recommend the specific section in Attachment A in which the information that supports this can be found is cited in the parentheses.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Attachment A, Section 4 will be cited in Section 7.6, Paragraph 2.

66) Section 7.7. It is stated for Option 4, that "The RIM material that would remain outside of the barrier wall is currently covered by 25 to 50 of solid waste and a landfill cover that prevents direct contact with the RIM and provides shielding from gamma radiation." Recommend units of measurement be inserted (i.e. "…25 to 50 'feet' of solid waste…").

Response: *The units of measurement for these values are indeed "feet".*

67) Section 7.7. It is stated for Option 4, that "Installation of heat extraction points is a common technology used for geothermal energy development and therefore this alternative is technically feasible." However, it comes down to the numbers. How do the proposed conceptual design conditions compare to the design conditions for a typical system that comprises this common technology? Do geothermal systems exist that have design conditions that are in the same neighborhood of the conditions that will exist within the SSE?

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Response:

Bridgeton Landfill initiated a pilot-test of heat extraction technology in the South Quarry area in August of 2014 and has expanded the scope of this test twice over the subsequent year. A report of the results obtained during the first year of operation of the pilot test was submitted early August 2015. See the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015.

Bridgeton Landfill is also seeking approval from MDNR to continue operation of the pilot test beyond the one year period. The results of the pilot test will be used as the primary basis for design of any future heat extraction systems that may be installed at the site. The area in the northern portion of the North Quarry/southern portion of Area 1 where a heat extraction system potentially could be installed and operated is sufficiently large to allow for installation of additional lines of heat extraction points if and as necessary. The cooler currently being used for heat removal could be supplemented, if necessary with a refrigeration unit to increase the rate of heat extraction. However, the improvement in extraction rate is relatively small with respect to the lateral zone of influence. This is due to the anticipated relatively small change in heat extraction arising from the difference in temperature between the target value of 175° F and the average value of evaporative cooling (50° to 55° F) versus a chilling temperature of 20 degrees F. Current data suggest that a rise from 45° F to 80° F did not significantly affect the removal rate of points in the heat front (see GIW 10 for example in the August 15 report).

Options such as these can be evaluated as part of the design phase based on results obtained from the heat extraction pilot test and even later during construction and operation of a heat extraction system, if necessary, based on application of an observational engineering approach to evaluation and modification of such a system.

In August 2015 a report titled "Expanded Heat Removal Pilot Study Initial Report" was submitted to the MDNR. This report described the removal of over 1 billion BTUs of heat from the northern portion of the South Quarry and provided information which can be used to estimate heat flux, thermal conductivity, etc. In addition, by November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.

68) Attachment C, Section 1.1. It is stated that "The primary data parameters recorded…" from the single well, GIW-4, "…were the inflow and outflow water

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temperatures, flow rate and the temperature within the casing as measured by thermocouples at multiple depths. Where is that data, specifically the water flow rates and the entering and leaving water temperatures? Recommend that data be included in the report to as an attachment to support the claim of feasibility.

Response:

A report providing the results of the operation and monitoring of the heat extraction pilot study was submitted to MDNR in August of 2015. See the "Expanded Heat Removal Pilot Study Initial Report." In addition, the information gathered in the GIW – 4 initial program is included in this report.

69) Attachment C, Section 1.3. It is stated that "Estimates of the maximum heat flux in the south quarry have been in the range of 14 Watts/sqm, as of July 2013." This rate is very low. This rate is slightly less than 5 Btuh/sqft, which, as a comparison, would not fully heat a typical building to typical occupied conditions in the warmest areas of this country. Over what area is this rate determined? What is the total heat to be rejected by the system?

Response:

The value was estimated for each square meter measured along an imaginary line with a depth of about 20 meters. In other words a total flux per running meter in plan view of 280 watts. The calculation supporting this value was developed in August 2013 and is attached (see Attachment G).

70) Attachment C, Section 2.2. It is stated that the vertical heat extraction elements be comprised of corrosion resistant metal (low carbon stainless steel) or nonmetallic materials. Metallic materials underground may required cathodic protection while temperature limitations maybe an issue for nonmetallic materials. It is recognized that this is a design issue that will need to be considered during design.

Response: *Comment noted. We concur that cathodic protection may be required for metallic elements installed in the subsurface and that this is a factor that will need to be evaluated as part of the design effort.*

71) Attachment C, Section 2.3. Please confirm that the proposed design delta temperatures for a cooling tower powered system are 175 degrees F minus 85 degrees F or 90 degrees F.

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Response:

No proposal for use of any chiller powered system has ever been made. The barrier design would be based on a worst case condition of a design heat removal value to attain no greater than 175 degrees F at the compliance point within the waste. The temperature of the liquid returning to the tower would not likely exceed 100 degrees F. The conditions under which the cooler would operate would be 85 degrees F maximum (or up to 90 degrees) – for the supply side water leaving the cooler. Annually, the cooled liquid temperature would be close to the average dew point, but not less than 40 degrees F to prevent issues with the cooler. It may be possible to modify the cooler controller to allow temperatures lower than 40 degrees F; this would be considered in final design. Flow rates and spacing of elements would be sized accordingly based on these constraints. The lower temperature mentioned represents the liquid temperature leaving the cooler unit during the months of November through March (on average).

72) Attachment C, Section 2.3. Please confirm that the proposed design delta temperatures for a chiller powered system are 175 degrees F minus 40 degrees F or 135 degrees F.

Response: *Please see the response to comment no. 71.*

73) Attachment C, Section 2.3. It is stated that "These systems will be above ground HDPE pipe with flex connections to the extraction points." Typically, we only see HDPE pipe installed below grade due to issues with UV. How will this be addressed? It is recognized that this is a design issue that will need to be considered during design.

Response:

The HDPE pipe loops will be insulated and not exposed to UV. Use of exposed UV resistant piping is also considered acceptable. In addition, all exposed piping will be inspected regularly and as such can be repaired or replaced if needed.

74) Attachment C-General. The issue with utilizing typical HVAC machines in this situation is that the equipment pretty much does what it was designed to do, which is not a delta temperature of 90 to 135 degrees F. Specifically, vapor compression chillers typically will not produce a delta temperature above 20 degrees F and will shut down on a safety if entering water temperatures become too extreme. With a flowing fluid, do you intend to use equipment in series to achieve the necessary temperature differential? Do you know of a specific chiller that is capable of these high temperature drops?

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Response:

This comment seems to be based on a misunderstanding of the proposed system. See the response to Comment #71 for the thermal design conditions. The closed loop cooler to be used will be similar to the one currently being used in the Heat Removal Pilot Study, and will be sized accordingly based upon the thermal design during the actual barrier design process. Specifications pertaining to the cooler being used in the Pilot Study are included in the Attachment D..

75) Attachment C, Pg 3, 2nd Bullet. Why was a point of compliance of 15-ft north of the cooling elements selected for Option 4?

Response:

The point of compliance was placed to the north of the cooling points to allow installation of monitoring points between the point of compliance and the cooling points and to allow for installation of additional cooling or monitoring points if needed based on observations of the effectiveness and performance of the system. The design of the point of compliance and associated monitoring network can be further evaluated during design phase.

76) Drawing 16. The Option l and 3 Typical Inert Barrier shows the barrier centerline located in the center of the flat work area. To accommodate the heavy excavation machinery and tooling, the Inert Barrier must be located approximately 45 to 50 feet away from either edge. USACE studies of slope stability show that better global stability factors of safety are obtained when the heavy excavation machinery and tooling is located on the side of the trench opposite the taller excavated slope.

Response:

Comment noted; we appreciate your feedback regarding slope stability. Future drawings will be modified to illustrate the barrier excavation location 45 feet from the shorter excavated slope.

77) All Drawings. All drawings show historical boundaries. Recommend these drawings be updated to reflect current contaminant boundaries with a dashed line where the extent of contamination has not been determined.

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Response:

All future drawings will include the extent of Area 1 and the revised extent of RIM in Area 1 based either on the preliminary evaluation of the extent of RIM to be presented in the Comprehensive Phase 1 reports or the final determination to be presented in the Supplemental SFS report.

78) Drawings 002 and 009. The eastern limits of the Option l and Option 2 alignments shown on Drawings 002 and 009 appears to violate the location of the North Quarry wall shown on Figure 2 of Part I of the Bridgeton Landfill Contingency Plan. Please verify that the proposed alignments do not violate the quarry wall and indeed meets the assumed 45-degree offset.

Response:

The 45-degree offset is a rule-of-thumb industry standard to avoid substantial settlement based upon the deep quarry along the western edge of the site. The entire barrier will need to be subjected to a thorough deformation analysis considering the projected barrier alignment.

In addition, the North Quarry geometry is such that there are two steps to the lower quarry floor elevation. Along the east, the first ledge is approximately 80-90 feet below the ground surface. The 45 degree offset was a design rule of thumb to avoid deeper fills over 150 feet. The eastern alignment avoids the deeper fills by over a 45 degree offset.

79) Drawings 003 and 010. Each of these drawings include values of pre-excavation and barrier excavation volume. Recommend also showing the overall volume needing to be relocated.

Response: *The overall volume of materials to be relocated will be added to any future drawings.*

80) Sections 3.5, 3.6, 3.7, 4.5, 4.6, 4.7, 5.0, 6.5, 6.6, 6.7, 7.4, 7.5, 7.6, 7.7, and Attachment D. There is still no Bird Monitoring and Control Plan to review. The sections reviewed considered the concerns of the St Louis Airport Authority and consistently assessed the concerns of quantity of waste and duration of exposure and the impacts those two things have on Bird Airstrike concerns. A new Alternative, Heat Extraction Barrier, was introduced that has less bird airstrike implications than the other options. There was not much emphasis placed either on covering excavated waste or in handling and transport of waste for installation of the isolation barrier. This should be covered in the forthcoming Bird Monitoring and Control Plan.

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Response: *A revised bird mitigation plan was recently completed and is included as an attachment to these responses to comments on the Isolation Barrier Alternatives Analysis.*

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City of St. Louis, owner and operator of Lambert-St. Louis International Airport Comments

General Considerations

As you know, the City holds a negative easement at the Bridgeton Landfill and certain areas in the vicinity of the Bridgeton Landfill to ensure that the landfills in this area will not pose a bird hazard to aircraft. Putrescible waste attracts birds, which create a safety hazard to air navigation. Any new operation that exposes putrescible waste in such close proximity to the Airport could result in a new bird hazard to aircraft, impacting the safety of the 13 million plus passengers who fly in and out of the Airport every year. The City's considerations with the options set forth in the Study focus on the amount putrescible waste that would be exposed under each option, on the length of time such waste would be exposed, and on the manner in which the waste is extracted and exposed. The more putrescible waste is exposed, the longer the term of the exposure, and the larger the area of exposure, the greater the potential for a bird hazard to aircraft. Any option chosen by the EPA that would expose putrescible waste must include a robust wildlife hazard identification, monitoring, mitigation, and elimination plan to identify the potential for bird hazards very early, before any bird activity is established because once a bird hazard to aircraft develops, it is much more difficult to control and eliminate.

As you are aware, the City has reviewed and approved BL's Bird Hazard Monitoring and Mitigation Plan for Ongoing Landfill Work (Revised June 24, 2014), which deals with limited ongoing work as defined and provided for therein and expressly excludes more extensive waste disturbance like the construction of an isolation barrier but does include monitoring and mitigation of bird issues regarding the basins at the Site. As the City has articulated in previous correspondence to the EPA, any time putrescible waste is excavated or exposed at the Site, a bird monitoring and mitigation plan containing the elements set forth below must be implemented. The more putrescible waste exposed, the more rigorous and detailed the plan must be. The necessary elements of a bird monitoring and mitigation plan for an isolation barrier plan must include the following:

1) Mitigation measures during work. Mitigation measures during excavation of putrescible waste to minimize bird attractants must be an integral element of any work plan and these measures need to be implemented throughout the time that any putrescible waste is exposed. Depending upon the particular work, the measures may include routine covering of excavated materials, closed containers, rapid off-site waste disposal or other measures to minimize the exposure of putrescible waste to wildlife. In addition, any work that will cause the on-site pooling of storm water runoff or other water must be designed to minimize the time that pooled water accumulates.

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Response: *Measures outlined in this point are routinely undertaken in the existing bird control program and will be continued in the identified bird control programs. The control of exposed waste is discussed in each of the control programs, as appropriate.*

2) Appropriately trained personnel. All mitigation and monitoring measures must be developed or approved by and work supervised by professionals trained in wildlife management and control. The professionals must have appropriate experience not only in wildlife management, but also in means to identify and control wildlife hazards. Training comparable to FAA Advisory Circular 150/5200-36A as may be amended, or alternative training and experience reasonably approved by the City is necessary.

Response:

Bird controllers identified in the bird mitigation plans will have appropriate training in wildlife control. They will take the training courses given by USDA Wildlife Services staff. In addition, the controllers will be given advanced training in landfill bird control by experienced biologists from LGL Limited. LGL Limited will provide supervisory services to insure that the control program is operating properly.

3) Daily monitoring. Monitoring for bird hazards by trained personnel on at least a daily basis at all times when putrescible waste is exposed. At a minimum appropriately trained personnel must be on-site on a daily basis to monitor, assess and document bird populations and identify any potential bird hazard during active excavation. It is essential to timely identify the creation or development of a bird hazard so that it may be eliminated quickly before aircraft safety issues develop.

Response:

The coverage by the bird controllers will exceed the above requirement. For the two most problematic barrier options, full-time controllers will be on duty from dawn to dusk, seven days per week while the waste is exposed. The controllers will not have other duties beyond documenting and controlling potentially hazardous bird species.

4) Control measures. If monitoring indicates a bird population increase or a potential bird hazard, the plan must call for additional measures to control and eliminate birds. These control measures must be directed and implemented by appropriately trained individuals. A robust and flexible bird repellant program must be implemented including escalating measures such as an intensive harassment program including the use of pyrotechnics, propane

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cannons, trapping and, where necessary, lethal control to ensure birds do not congregate at the Site. Appropriate equipment for dispersing birds must be on-site at all time and staff must be properly trained in the equipment use and application.

Response:

The bird control plans are designed so that the full-time controllers take action as soon as potentially hazardous birds show an interest in the site. Those birds are immediately scared off by the proper use of pyrotechnics. By using this approach, bird numbers will be minimized at the site and hazards will be avoided. Waiting for bird numbers to increase before initiating control is not an option and just makes control more difficult.

5) Reporting. The City will need weekly reports of bird populations and immediate reports of any bird hazard identified during any time periods when putrescible waste is exposed.

Response:

The bird control plans make provision for weekly reports to be prepared and submitted to the City. The reports will document bird species and numbers seen on the site and will document control efforts that were undertaken.

6) Reimbursement agreement. Before construction starts, the City will need to have in place an agreement with BL to reimburse the Airport for expenses associated with monitoring and, if necessary, responding to any bird hazards at the landfill during the project due to BL's refusal or failure to timely respond.

Response:

A reimbursement agreement between the City and BL will be negotiated and signed before any project begins. BL has every intention of insuring that any project conducted will not create a hazard to aircraft using the airport.

Isolation barrier plans that require excavation of large quantities of putrescible materials will necessarily require a much more detailed bird management and control plan, especially in terms of mitigation measures, than barrier plans with minimal or no waste excavation.

Response:

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The bird control plans developed and submitted with this response document (see Attachment I) recognize the differences in the bird control efforts needed for the various options based on the amounts of waste excavated.

Comments on Individual Options

We reviewed the Study including Mr. Rolph A. Davis, Ph.D. report dated October 7, 2014, attached as Exhibit D to the Study and entitled "Isolation Barrier Alternative Analysis – Bird Control Issues". The City concurs in general with Dr. Davis's evaluation of the various options and agrees that the final details of the bird management and control plan will need to be determined in coordination with the City during the engineering phase of the project once the barrier option has been selected. Listed below are the City's comments on the individual options.

No Action. The Study indicates that the No Action alternative would not create additional bird attractions. The City will point out that even under the No Action alternative, measures that are currently being implemented would be continued and such measures do have the potential to attract birds since additional storm water detention is occurring and some excavation is necessary to maintain wells and perform other activities associated with the landfill cap. The City acknowledges, however, that if landfill personnel are appropriately trained and the current Bird Hazard Monitoring and Mitigation Plan is implemented, unmanageable bird hazards are not anticipated.

Response:

No response needed.

Option 1: Inert Barrier Along Alignment 1. The Study indicates this option involves the excavation of 52,000 bank cubic yards ("bcy") of putrescible waste and the redeposition of this waste on-site. Approximately seven acres of disturbed putrescible waste would be involved and waste would be exposed for 40 weeks. The City agrees that this option poses a strong potential for the exposure of waste that will attract wildlife to the excavation and redeposition areas. A rigorous bird hazard and mitigation plan would need to be implemented and the project itself will need to be designed to minimize exposing putrescible waste. In addition, since the potential for a bird hazard cannot be known completely until the work is in progress, the project plan will need to include the ability to halt construction, eliminate hazards and design additional bird hazard mitigation measures during construction, if a bird hazard develops.

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Response:

A rigorous bird control plan has been designed and is submitted with this response to comments (see Attachment I). The program includes continuous bird control during all daylight hours and will prevent use of the site by potentially hazardous birds. Nonetheless, the plan includes provision to increase control effort in the unlikely event that such an increase is necessary.

Option 2: Air Gap Barrier. This Option 2 was not proposed for additional detailed evaluation due to the significant disadvantages associated with this approach as set out in the Study. The Study does indicate that at least 540,000 bcy of waste would need to be excavated to implement this option and the option would involve 400 days of excavation. It appears that the areas of waste exposed could exceed the areas found in typical operating landfills, which pose a bird hazard to aircraft operations when located in close proximity to airports. Since such hazards generally cannot be mitigated successfully, operating landfills are prohibited in proximity to an airport (*see Hazardous Wildlife Attractants On or Near Airport – Advisory Circular 2150/5200-33B*). It is very doubtful that any excavation under this option could be successfully implemented without creating substantial risk hazards to air navigation.

Response:

As noted, this option is no longer under consideration.

Option 3: Inert Barrier Along Alignment 3. The Study indicates this option involves the excavation of 63,500 bcy of waste and redeposition of waste on-site. Approximately seven acres of disturbed putrescible waste would be involved and waste would be exposed for 48 weeks, including newer waste that may be more attractive to birds. Similar to Option 1, the City agrees that this option poses a strong potential for the exposure of waste that will attract wildlife to the excavation and redeposition areas. A rigorous bird hazard and mitigation plan would need to be implemented for this project and the project itself would need to be designed to minimize exposing putrescible waste. In addition, since the potential for a bird hazard cannot be known completely until the work is in progress, the project plan will need to include the ability to halt construction, eliminate hazards and design additional bird hazard mitigation measures during construction, if a bird hazard develops.

Response:

A rigorous bird control plan for this option has been designed and is submitted with this response to comments. The program includes continuous bird control during all daylight hours and will prevent use of the site by potentially hazardous birds. Nonetheless, the plan

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includes provision to increase control effort in the unlikely event that such an increase is necessary.

Option 4: Heat Extraction Barrier. The Study indicates that no or only minimal waste excavation/relocation is anticipated to be necessary to implement the heat extraction barrier so that no bird mitigation/management measures are necessary. The City is skeptical that no waste will be excavated to implement this remedy; however, this option appears to pose a very low chance of developing a bird hazard to aircraft. Given that work would be conducted within the waste material, the City would expect a bird hazard monitoring and mitigation plan to be developed for the work. However, unmanageable bird hazards are not anticipated under this option.

Response:

It is agreed that this option will not likely create a bird hazard. However, the surface activity involved could attract curious birds, primarily gulls looking for food. See the control program that is proposed and is attached to this response to comments (see Attachment I). The plan involves one full-time controller on site for five days per week. Standard weekly reports to various agencies would be submitted.

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Missouri Department of Natural Resources Comments

Hazardous Waste Program Comments:

Bird Mitigation Plans

The third sentence of the first paragraph of Section 1.0, Introduction, states, "In the August 26, 2014 letter transmitting the USACE report (EPA, 2014a), the United States Environmental Protection Agency (EPA) requested the Respondents to use the USACE report "…as a basis to further develop more detailed plans for the Isolation Barrier, specifically including bird mitigation plans, for each of the proposed alignment alternatives." The document goes on to state that a meeting was held on September 18, 2014 between EPA and the Responsible Parties. The EPA memorialized the meeting and refined the scope of work to be performed by an email dated September 23, 2014. This email again requested bird mitigation plans for select alternatives, as well as including additional evaluations for "No Action" and "Proposed Cooling Wall" alternatives.

Based on the initial scope of the request and further direction from EPA, bird mitigation plans should have been included in the analysis for Options 1, 3 and 4. The discussions within the analysis evaluate the potential for each alternative to attract birds, but not how to mitigate this potential. Furthermore, Attachment D, Isolation Barrier Alternatives Analysis – Bird Control Issues, appears to also focus more on bird attraction potential and the need for a bird control program with little details on the design and implementation of such a program. However, it is noted that Attachment D, Section 5.0, states in reference to Options 1 and 3 that, "The two options have the same bird hazard risk which can be well-controlled in either case." We strongly recommend EPA require the Respondents to prepare detailed bird mitigation plans for the alternatives, as initially directed by your agency.

Response:

Revised bird mitigation plans were recently completed for each Barrier Option; those plans are included as part of the submission of responses to comments on the Isolation Barrier Alternatives Analysis (see Attachment I).

Reference to the Draft Subsurface Smoldering Event (SSE) Impact Evaluation

The analysis references the document titled *Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision Selected Remedy for Operable Unit-1 at the West Lake Landfill* (SSE Impact Evaluation) and states that revisions to the report and responses to comments are currently in progress. Revisions to the "SSE Impact Evaluation" may affect the conclusions of this document. We suggest EPA

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require the Respondents to address comments provided by Mr. Todd Thalhamer, P.E. and the MDHSS and finalize the "SSE Impact Evaluation" document before using it as a reference for this analysis.

Response:

EPA previously indicated that no revision of the SSE report was required but that the comments should be considered in the evaluation of potential impacts from the SSE in the Supplemental SFS report. Nothing in the document referenced in the comment indicates a different approach.

In addition, "Section 3.6.2 Potential Impacts if a SSE were to Occur in Area 1", the third sentence of the second paragraph states, "The EPA-ORD comments indicated that EPA generally concurred with the three points listed above; however, EPA-ORD did offer additional points in particular highlighting its opinion that if a SSE were to occur in OU-1 it could create the potential for additional leachate generation." EPA-Office of Research and Development (ORD) also commented on the potential for release of fine particulates. EPA-ORD comment on Bullet Point #2 states, "Surface cracks and fissures may allow gases (such as radon and steam) to escape, and potentially create conditions that could allow fine particulates to escape from the landfill." We suggest EPA require the Respondents to include this potential exposure pathway in the analysis.

Response:

This potential exposure pathway has been considered as part of the evaluation of potential increase in radon emissions included as Attachment A to the report. With respect to potential additional leachate generation, please see the response to USACE comment no. 21.

"No Action" Protective of Human Health

Section 3.7 of the document and Table 1 identifies the "No Action Alternative" as being protective of human health and the environment. This is inconsistent with the summary of risks as presented in the Supplemental Feasibility Study (see Section 2.5.1). Such a conclusion also contradicts the necessity of a remedy for Operable Unit 1, Area 1.

Response:

The Isolation Barrier No Action Alternative is considered to be protective of human health and the environment relative to potential impacts or risks associated with a hypothetical occurrence of an SSE in Area 1 and was not intended to provide a broader conclusion relative to Area 1 (or Area 2) overall. The statement regarding the

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protectiveness of the Isolation Barrier No Action Alternative was only intended to address potential risks associated with a possible SSE in Area 1 and does not imply that the broader No Action Alternative for OU-1 was protective of human health or the environment.

Additionally, the document does not quantitatively assess the risks associated with other potential pathways identified by EPA-ORD, MDHSS, and Mr. Todd Thalhamer, P.E. Therefore, the conclusion that "No Action" is protective of Human Health is not supported by the record (see Department letter dated April 24, 2014, Enclosure: Memorandum from Mr. Todd Thalhamer, P.E., dated April 14, 2014).

Response:

We disagree with MDNR's assertion that the "No Action" Alternative is not supported by record evidence. In particular, the IBAA assessed the potential risks associated with a hypothetical occurrence of an SSE in Area 1. EPA (the agency with primary jurisdiction over the RIM at West Lake Landfill) has indicated that "[t]he specific arguments postulated in this document in relation to the heat's effect on the radiologically- impacted material (RIM) and therefore radon flux in Attachment A are well thought out and present plausible scenarios considering an event occurring is a low probability." Many of Mr. Thalhamer's comments go beyond the scope of the SSE evaluation requested by EPA; however, to the extent those comments have technical content, they may be addressed as appropriate as part of the SSE evaluation to be included in the Supplemental SFS report.

In "Section 3.6.2, Potential Impacts" if a SSE were to occur in Area 1, the first sentence of the third paragraph states, "Because the RIM would remain buried beneath other waste materials and soil or inert fill, no changes in other exposure pathways (direct contact with or dermal exposure to the RIM or exposure to gamma radiation) are expected to occur if a SSE were to migrate into Area 1." This statement appears inconsistent with current site conditions. The Remedial Investigation and other documents/site observation conclude that radiologically-impacted materials (RIM) occur at or very near the highly vegetated surface and are not buried by other waste material, soil, or inert fill. We suggest EPA require the Respondents to revise this document and the "SSE Impact Evaluation" document, to include analysis of risk associated with conditions that could be created by an SSE or a surface fire.

Response:

The analysis assumed that the ROD-selected remedy would be implemented (otherwise what possible need would there be for an Isolation Barrier?) which requires construction of an engineered landfill cover over Areas 1 and 2. After a new engineered landfill cover

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is constructed, there would not be any direct contact, dermal exposure or gamma radiation exposure from the RIM in Areas 1 or 2.

RIM Relocation on Area 1

The discussions for Options 1 and 3 (Sections 4.7 and 6.7) describe relocation of RIM onto Area 1. This contradicts the USACE document which states that RIM waste excavated as part of wall installation will require off-site disposal. We suggest EPA require the Respondents to revise the document to be consistent with USACE recommendations.

Response:

The discussions are consistent with USACE recommendations. A final determination regarding relocation and consolidation of wastes (RIM or non-RIM) on-site versus off-site transport and disposal of RIM or non-RIM wastes that may be excavated as part of construction of a possible isolation barrier has not been made. Depending upon the nature of the potential isolation barrier alternative, if any, that may be implemented, the volumes of waste materials (both RIM and non-RIM) that may be excavated and therefore need to be relocated on-site and/or disposed off-site are highly variable, ranging from zero or near zero up to approximately 100,000 cubic yards. EPA previously requested the Respondents evaluate potential locations and available volumes for relocation of waste on-site. If an isolation barrier were to be installed, it would be done in conjunction with a decision to leave the RIM on-site and implement the ROD-selected remedy (i.e., a thermal isolation barrier to prevent migration of an SSE from the South Quarry from reaching the RIM in Area 1 would not be necessary or appropriate if EPA were to ultimately abandon the ROD-selected remedy and select a different alternative for OU-1).

Assuming that the ROD-selected remedy is implemented, on-site consolidation in Area 1 of any RIM that may be excavated during construction of a possible isolation barrier would be an appropriate management method for such materials. As opposed to off-site transport and disposal, on-site consolidation of such waste would:

- *Not contribute any additional long-term risks for Area 1 (i.e., the materials that may be relocated would have overall lower activity levels compared to other materials in Area 1 and all of these materials would be consolidated under a new engineered landfill cover);*

- *Eliminate potential risks associated with off-site transport and disposal;*

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- *Minimize the amount of handling and potential exposure duration associated with management of any RIM wastes that may be encountered; and*

- *Contribute to the overall regrading of the configuration of Area 1.*

Therefore, on-site consolidation of any waste materials (RIM or non-RIM) that may be excavated during potential installation of an isolation barrier should continue to be considered as part of the evaluation of possible isolation barrier alternatives.

Need for Further Characterization of RIM

In "Section 2.1, Isolation Barrier Alternatives", the first sentence of the last paragraph states, "The USACE report also considered an additional alignment (Alignment 2) that would consist of installation of an inert barrier located south of OU-1 Area 1 to ensure that all RIM is located to the north of the Isolation Barrier." Full characterization of RIM is necessary to support this consideration. The Department notes that the USACE document states in Section 1, Key Point #1 as follows:

"The full extent of the RIM has not been determined, specifically in the southwest portion of OU1 Area 1, east of and around the existing Transfer Station. Before design work can be completed for the IB, additional subsurface investigative work is necessary to determine the limits of the RIM as well as to collect geotechnical data necessary for the design of the IB."

The Department supports USACE's conclusion with respect to the design of the Isolation Barrier. Given slowly increasing temperatures in the neck, we further suggest EPA require the Respondents to immediately characterize RIM in the entire North Quarry. The Department's SWMP is currently requiring the installation of needed additional temperature monitoring probes in the neck area and this may provide an opportunity for the Respondents to do simultaneous RIM characterization.

Response:

A work plan for additional characterization of the extent of RIM in the southern and western portions of Area 1 has been prepared, submitted to EPA, approved by EPA and is currently being implemented.

We disagree, however, with MDNR's assertion that the entire North Quarry need be "immediately characterized" with respect to potential RIM. Extensive prior site characterizations conducted with EPA oversight demonstrate that there is no basis to conclude that there is any RIM in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1

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waste materials located beneath the northern extension of the aboveground portion of the North Quarry area of the West Lake Landfill, not within the North Quarry. Occurrences of radium in groundwater monitoring wells located adjacent to the North and South Quarry portions of the Bridgeton Landfill most likely reflect releases of naturally occurring radium in response to changes in groundwater geochemistry, specifically dissolution of iron and manganese hydroxides and other mineral assemblages that contain radium in response to occurrence of reducing conditions (technically termed reductive dissolution) created by microbial decomposition of the MSW (methanogenesis) or even more highly reducing conditions associated with additional oxygen consumption by the SSE in the South Quarry.

Solid Waste Management Program:

Missouri is a U.S. EPA approved state for implementation of Subtitle D of the Resource Conservation and Recovery Act (RCRA). Under 42 U.S.C. 6901-6991K and 40 CFR Parts 257 and 258 requirements, Missouri has authority to permit the design and operation of municipal solid waste disposal areas. All aspects of the design, operation, closure and post closure of these facilities fall under the authority of the Solid Waste Management Plan.

Response:

Comment noted. Bridgeton Landfill has and continues to work with MDNR regarding design, operation, closure and post closure of non-RIM solid waste at the West Lake Landfill. That said, responsibility for all aspects of the characterization and evaluation of remedial actions relative to occurrences of radionuclides at the West Lake Landfill is under primary EPA jurisdiction pursuant to CERCLA.

Solid Waste Management Program General Comments:

We were unable to ascertain that the alternatives considered comply with all Applicable or Relevant and Appropriate Requirements (ARARs). Specifically, under a CERCLA Removal Action, any staging, management and relocation of excavated wastes on the West Lake Landfill Superfund site must comply with all ARARs including Missouri Solid Waste Management regulations and siting requirements.

Response:

The factors used to evaluate the alternatives are presented in Section 2.2 (p. 4) of the report and are based on the factors identified by the USACE in its Isolation Barrier Alternatives Assessment report which EPA indicated in its August 26, 2014 letter the Responsible Parties should use as a basis to further develop more detailed plans for the

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Isolation Barrier alternatives. Evaluation of potential ARARs was not a factor identified by the USACE or EPA for evaluation of the Isolation Barrier alternatives and therefore was not addressed in the report. However future evaluations of possible isolation barrier alternatives, can, unless otherwise determined by EPA, include an evaluation of potential ARARs.

The lack of definition for the twelve assessment factors make it difficult to determine whether issues in managing excavation and movement of decomposing municipal solid waste were adequately considered in the Isolation Barrier Alternatives Analysis process. Associated factors which should be taken into consideration as part of this evaluation are discussed throughout the following comments.

Response: *Identification and definition of the twelve assessment factors and preparation of the Isolation Barrier Alignment Alternatives Assessment were performed by the USACE on behalf of EPA and therefore, comments on these items are more appropriately addressed to EPA and the USACE.*

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Solid Waste Management Program Section Specific Comments:

1.0 Introduction

The objective of the analysis does not consider the characteristics of the previous surface and subsurface fires that occurred in the North Quarry with temperatures that reached 800°F. Considering only temperature in a range similar to those found in the South Quarry subsurface smoldering fire, of approximately 300°F, is not sufficient for analysis of isolation barrier alternatives. (See "Task 4 Assessment of Results/Recommendations for Future Action Subsurface Combustion at Laidlaw Bridgeton Landfill" submitted by SCS Engineers for Laidlaw Bridgeton Landfill. The assessment report is available on the Department's website at http://dnr.mo.gov/env/swmp/facilities/docs/alldocs_19921994.pdf , pgs. 119-126 of the report.)

Response:

The 1993 fire adjacent to the quarry wall entailed active combustion of exposed waste under conditions of exposure to the atmosphere oxygen levels resulting in flaming combustion at temperatures much higher than those associated with the subsurface smoldering of waste under oxygen deficient conditions. In other words, the 1993 incident was indeed a fire, not a subsurface chemical reaction (as is currently occurring in the South Quarry). The evaluations requested by EPA were therefore appropriately focused on the effects and potential mitigation of an SSE, not an exposed fire.

Furthermore, due to incomplete characterization of radiologically-impacted material in the North Quarry, there is heightened concern with allowing any combustion to occur in that area. To address this concern, the SWMP on October 7, 2014 issued a letter to Bridgeton Landfill, LLC requiring submission of a corrective action assessment and plan that identified a corrective action zone encompassing the northern neck and the southern portion of the North Quarry. Bridgeton Sanitary Landfill must be positioned to immediately implement additional measures to contain the existing subsurface fire to the South Quarry area and to extinguish any independent fire or reaction that might occur in the North Quarry.

Response:

There is no basis to conclude that there is any RIM in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the above-ground portion of North Quarry area of the West Lake Landfill, not within the North Quarry.

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By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.

In addition, on September 9, 2015, Bridgeton Landfill submitted a plan to address isolated "hot spots" that may occur in the North Quarry independent of the SSE occurring in the South Quarry (see Attachment J).

In summary, consideration needs to be given to:

- The potential for waste materials in the North Quarry to combust at a significantly higher temperature than waste materials found in the South Quarry.

Response: *See response to previous comment.*

- Adequately characterizing waste materials and determining the extent of the radiologically-impacted material that might be affected by a smoldering fire originating in the North Quarry or moving into the North Quarry from the South Quarry.

Response:

As previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

- If combustion were to occur in the North Quarry, an understanding of the types of emissions that would be expected from the waste materials is needed, including any radiologically-impacted material.

Response:

As previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1

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investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

- Potential impacts of an additional smoldering fire on the grout or slurry used to extinguish the 1992-1994 subsurface/surface fire through oxygen deprivation. It is unknown how the injected material will behave as it dries and potentially crumbles allowing oxygen to infiltrate the waste mass, i.e. oxygenating the subsurface fire.

Response:

The response to the 1993 fire along the outer wall of the North Quarry included grouting of the bedrock adjacent to the waste mass, adjustment of landfill gas operations and placement of additional soil cover over the opening adjacent to the quarry high wall. All of these actions were taken to reduce the potential for introduction of oxygen into the waste mass. Current, ongoing landfill gas quality monitoring in the North Quarry near the location of the 1993 fire is consistent with typical landfill gas conditions and does not indicate the presence of elevated oxygen levels in this area.

3.0 No Action Alternative

As noted above in Section 1.0, it is imperative that Bridgeton Sanitary Landfill have readily implementable methods for addressing any northward progression of the subsurface fire into the North Quarry. The SWMP's October 7, 2014 letter to Bridgeton Landfill, LLC required submission of a corrective action assessment and a corrective action plan. The identified corrective action zone encompasses the northern neck and the southern portion of the North Quarry. Bridgeton Landfill has submitted a corrective action plan and the SWMP is currently reviewing that material for response.

Response: *By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.*

The No Action Alternative does not appear to fully consider the following:

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- The slowly upward trending temperature data reported by Bridgeton Sanitary Landfill in the Neck Area temperature monitoring probes is an indicator that the waste mass is slowly heating and drying out, which creates an unacceptable risk of combustion if there is movement of the South Quarry subsurface fire or development of a separate event in the neck.

Response:

Temperature monitoring of TMPs 1- 4 located in the neck area indicate that temperatures in this area are stable. Multiple air sampling events since 2012 support the proposition that the SSE is moving away from the neck, North Quarry and Area 1. Levels of constituents of concern found gas samples in the "neck" area of the landfill between the Landfill's North and South Quarries were significantly less than levels detected in this area in samplings in 2012/2013. A June 2015 air sampling study (Bridgeton Landfill Ambient Air and Landfill Source Gas Sampling-January 2015, Stantec, June, 12, 2015) submitted to MDNR (summarizing data from January 2015) noted that "[t]he concentrations and specific groups of constituents of concern in source gas from the Neck resemble source gas from the North Quarry where the subsurface reaction is not occurring."

In addition, Bridgeton Landfill initiated a pilot heat extraction test in the South Quarry near the neck area to evaluate the effectiveness of heat extraction in controlling temperatures and potential migration of an SSE from the South Quarry. By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.

- The presence of some radiologically-impacted material in the North Quarry (full extent unknown at this time) and the potential for that material to be affected by an independent smoldering fire occurring in the North Quarry given the existence of such an event currently in the South Quarry and previously in the North Quarry.

Response:

As previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1

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investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

- This option appears to place considerable weight on the unproven Heat Extraction Pilot Study. While the SWMP saw no technical reason for denial of the pilot study, we have yet to be provided any data to support that this ambient air cooler system, on its own, removes sufficient heat to halt progression of a smoldering fire.

Response:

A report providing data regarding the design, upgrades/expansions, operation, and monitoring results obtained as part of the first year of operation of the pilot-test was submitted in August 2015. See the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015.

At the present time, Bridgeton has expanded the heat removal pilot test to double the rate of heat removal, adding more removal locations. In August 2015 a report titled "Expanded Heat Removal Pilot Study Initial Report" was submitted to the MDNR. This report described the removal of over 1 billion BTUs of heat from the northern portion of the South Quarry and provided information which can be used to estimate heat flux, thermal conductivity, etc. By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis. This additional evaluation will provide an opportunity for significantly more information concerning the nature and quantity of heat generation and conduction. Therefore, Bridgeton has decided to accumulate more information prior to preparing predictions of the reaction progress and nature in the unlikely event that the SSE were to enter the North Quarry.

- No time frames were given for the provision of the heat transfer modeling and additional demonstrations and evaluations of factors controlling migration of the subsurface fire into the North Quarry; therefore it is unclear whether this information will be timely provided for use during the decision-making process for the isolation barrier.

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Response:

A report providing data regarding the design, upgrades/expansions, operation, and monitoring results obtained as part of the first year of operation of the pilot test has been submitted. See the "Expanded Heat Removal Pilot Study Initial Report" submitted to the MDNR in August of 2015. By November 1, 2015, Bridgeton Landfill will submit a technical evaluation and design of a heat extraction line to be located south of the "neck" between the North and South Quarries. The technical evaluation will leverage the results of pilot study and the results of finite element heat transport modeling (using the Program FEFLOW©). The heat extraction line may be installed on a contingent basis to be agreed between Bridgeton Landfill and the MDNR. This detailed technical evaluation and design would directly translate into a detailed design for a thermal barrier at one of the alignments considered in the Isolation Barrier Alternatives Analysis.

- The Department's contracted landfill fire expert, Mr. Todd Thalhamer, P.E. provided in a February 13, 2014 comment letter a discussion of risks associated with the subsurface fire coming into contact with radiologically-impacted material in the North Quarry. Such risks included the potential for smoke and dust generation from the interaction of the subsurface fire and waste material. Was consideration given to Mr. Thalhamer's comments?

Response: *Yes.*

- In a recent report, the USACE states that due to design considerations, construction of an isolation barrier is at least 18 months from beginning. While that schedule is detailed step-by-step, the unique urban setting of the West Lake Complex where thousands of people live and work must be considered in evaluating isolation barrier alternatives and all efforts for expedited timeliness in implementation should be applied.

Response:

The schedule was developed based on accepted engineering practices and consideration of the estimated scope and duration of the various tasks. We understand the desire of all parties to expedite all of the activities at the site and attempts will be made to optimize all schedules as appropriate based on accepted engineering practices, known or estimable scope and duration of the various tasks, recognition of the extensive agency involvement, review and comment periods, community concerns, and in the interests of all parties in making sure that any and all decisions are technically sound and consistent with accepted engineering practices.

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4.0 Option 1 - Inert Barrier Along Alignment 1 and
6.0 Option 3 - Inert Barrier Along Alignment 3

Consideration in regard to the inert barrier options should include the following:

- Early in the contingency planning process, the Department recommended construction of a fire break similar to these proposals between the neck area and the North Quarry. At that time, Bridgeton Landfill and their contractors indicated that such a fire break would prove ineffective and soon fail due to movement and desiccation of the reinforced concrete. Has additional information been provided by Bridgeton Landfill to address these concerns?

Response:

We are not aware of any such claim related to possible desiccation of concrete ever having been made by Bridgeton Landfill. Bridgeton Landfill's concern regarding construction of a physical barrier in the neck area was relative to the overall depth of waste in the neck area which is significantly greater than the depth of barrier proposed at the present time, and this is still a concern about any type of barrier in the neck other than a cooling loop system.

- If the North Quarry is impacted by the subsurface fire, how does EPA plan to evaluate the effectiveness of the engineering controls (i.e., EVOH Cap, gas extraction and control system) should radiologically-impacted materials surface as the waste mass is reduced?

Response:

This hypothetical question is best addressed to EPA (as the agency with primary jurisdiction over RIM at West Lake Landfill). Further, as previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

- Have feasibility evaluations been conducted with respect to hot spot removal of any radiologically-impacted materials in the North Quarry?

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Response:

An evaluation of a potential hot spot removal alternative was performed as part of the original Feasibility Study (EMSI, 2006). In addition, per EPA direction, an evaluation of one or more partial excavation alternatives will be performed as part of the Supplemental SFS report.

However, as previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

- The heat exchange tubes being considered for placement in the reinforced concrete do not appear to be a proven technology. Are there practical examples of such heat exchange tubes being used in similar applications?

Response:

Yes, there are similar applications to heat exchange tubes. Bridgeton Landfill is currently employing heat exchange tubes in conjunction with the Heat Extraction Pilot Study. For reinforced concrete, removal of the hydration heat during construction is important, and installation and use of metal pipe in concrete is a common technique as demonstrated by the use of such pipes in dam structures such as the Hoover Dam.

- Given the historic subsurface fires in the North Quarry, was consideration given to using chilling or ground freezing technologies rather than adiabatic air coolers to ensure the area around the reinforced concrete barrier is maintained at a temperature to lengthen the life of the non-combustible element? While mention is made to electrical continuity cables being installed at approximately 20 foot centers, the ability of the cooling elements to move and remain operable as shifting and/or deformation of the non-combustible element of the structure occurs from waste reduction settlement is not clear and needs to be further assessed.

Response:

We reiterate that the SSE occurring in the South Quarry is not a "fire" and therefore cannot be compared directly to prior fires at Bridgeton Landfill. However, the thermal design parameters are included in response to the USACE's comment #71. It is not necessary to cool the water by a large degree. While chilling can be a contingency, it

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consumes large amounts of energy without providing significant advantages in the actual cooling process. Assessments of the ability of the heat exchange elements to tolerate movement will be included in the final designs.

- It is unclear why only on-site relocation of exhumed waste was considered. The sole safety factor expressed appears to be limiting the number of trucks leaving the facility. Was direct load and hauling of waste materials considered in these alternatives? This approach would limit odor generation as it relates to being a public nuisance, as well as avoiding undo bird attraction. Direct load and hauling would also greatly reduce the potential for a combustion event in any on-site areas of the relocated waste.

Response:

As previously discussed, EPA requested the Respondents evaluate potential locations and available volumes for relocation of waste on-site. That said, a final determination regarding relocation and consolidation of wastes (RIM or non-RIM) on-site versus off-site transport and disposal of RIM or non-RIM wastes that may be excavated as part of construction of a possible isolation barrier has not been made. Depending upon the nature of the potential isolation barrier alternative, if any, that may be implemented, the volumes of waste materials (both RIM and non-RIM) that may be excavated and therefore need to be relocated on-site and/or disposed off-site are highly variable, ranging from zero or near zero up to approximately 100,000 cubic yards. If an isolation barrier were to be installed, it would be done in conjunction with a decision to leave the RIM on-site and implement the ROD-selected remedy (i.e., a thermal isolation barrier to prevent migration of an SSE from the South Quarry from reaching the RIM in Area 1 would not be necessary or appropriate if EPA were to ultimately abandon the ROD-selected remedy and select a different alternative for OU-1).

Assuming that the ROD-selected remedy is implemented, on-site consolidation in Area 1 of any RIM that may be excavated during construction of a possible isolation barrier would be an appropriate management method for such materials. As opposed to off-site transport and disposal, on-site consolidation of such waste would:

- *Not contribute any additional long-term risks for Area 1 (i.e., the materials that may be relocated would have overall lower activity levels compared to other materials in Area 1 and all of these materials would be consolidated under a new engineered landfill cover);*

- *Eliminate potential risks associated with off-site transport and disposal;*

- *Minimize the amount of handling and potential exposure duration associated with management of any RIM wastes that may be encountered; and*

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- *Contribute to the overall regrading of the configuration of Area 1.*

Therefore, on-site consolidation of any waste materials (RIM or non-RIM) that may be excavated during potential installation of an isolation barrier should continue to be considered as part of the evaluation of possible isolation barrier alternatives.

- It is also unclear whether consideration was given to limiting the size of the working face. This is routinely done in construction projects involving exposure of decomposing municipal wastes. Soil, foaming and other products can be applied to exposed wastes to assist in managing odors from excavation activities and reduces the area of exposed waste materials that might act as a bird attractant.

Response:

Section 4.0 & 6.0, Bullet 7. Consideration will be given to methods that could be used to limit the size of the working face. It will be the goal of this project to have the least amount of exposed waste materials as possible, with any open excavation area and materials to be covered as soon as possible. However, use of alternative daily covers and limiting the size of the working face increases the time for waste relocation.

Given the existence of RIM in the northern portion of the North Quarry, evaluation of isolation barrier alignments in the southern-most portion of the North Quarry, or other engineering control options, need to be included in the analysis.

Response:

Evaluation of an isolation barrier in the southern-most portion of the North Quarry is outside the scope of work identified by EPA for the Isolation Barrier Alternatives Analysis. Furthermore, as previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

EPA requested additional evaluation of isolation barrier alternatives to be located between Area 1 and the North Quarry portion of the Bridgeton Landfill. Placement of a physical barrier or other engineered measure in the southernmost portion of the North Quarry is not considered to be effective with respect to Area 1 or implementable. With regard to effectiveness, although a barrier placed in the southern portion of the North Quarry could limit migration of the existing SSE in the South Quarry, it would not

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provide any protection if an SSE were to occur further to the north and east in the North Quarry. Installation of a physical barrier is not considered to be feasible due to the depth of waste in the southern portion of the North Quarry.

Bridgeton Landfill is currently implementing a heat extraction pilot test in the South Quarry portion of the Bridgeton Landfill to evaluate the potential effectiveness of this technology to limit heat transfer and possible migration of the SSE the South Quarry. Bridgeton Landfill has also committed to conduct an evaluation of technologies that may be used to halt any potential movement of the South Quarry SSE identified to be occurring in the neck area to the north of the gas interceptor wells.

5.0 Option 2 - Air Gap Barrier

This option was not evaluated and comments are not provided.

Response:

Comment noted. As documented in the report, all parties (EPA Region VII, EPA ORD, the USACE and Bridgeton Landfill) agreed that the negative aspects associated with possible implementation of this alternative outweighed its potential benefit. There was also concern raised about the feasibility of implementing such an alternative due to the estimated large volume of waste that would need to be excavated, surface water management issues associated with such a large open cut within the landfill, and the administrative feasibility of such an alternative relative to the concerns raised by the Airport authority and its existing negative easement on the property.

7.0 Option 4 - Heat Extraction Barrier

Consideration with respect to the heat extraction barrier option should include the following:

- As noted in the alternatives above, the Heat Extraction Pilot Study is a study of an as-yet unproven, new technology.

Response:

We do not agree with this comment. Heat extraction is not a new or unproven technology; rather, it has been used for centuries and is currently undergoing extensive use in geothermal energy production. The primary question that exists relative to its application at the landfill is the number of extraction locations that may be needed to cool the waste materials to the degree necessary to prevent occurrence or migration of an SSE. With enough extraction points, temperatures will be lowered to point where an

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SSE cannot occur. The technology is very scalable and more elements can be added at any time. Further, the current pilot studies have shown that significant energy can be removed from a single location.

- The potential for waste materials in the North Quarry to combust at a significantly higher temperature than waste materials found in the South Quarry does not appear to have been considered. What temperatures will the heat extraction (cooling) points be able to withstand? Can the heat extraction (cooling) points be constructed to connect to a chiller or freezing unit rather than an adiabatic air cooler?

Response:

In the event of an actual flaming combustion occurrence, a phenomenon that has not been observed in the South Quarry associated with the settlement and warming of the South Quarry waste, standard measures of managing or extinguishing the combustion would be employed. Bridgeton Landfill recently completed an Evaluation of Remedial Action Approaches for Hot Spot Remediation (see Attachment J) to address the unlikely potential for occurrences of temperatures above normal landfill conditions in the North Quarry area,

As a matter of record, Bridgeton does not agree that the current elevation of heat in the South Quarry is a "combustion event" or related to burning of waste material. The heat extraction system is not envisioned to be designed to extinguish a "combustion" event, although cooling of the waste and the associated moisture content rise of the cooled waste due to condensation of water vapor in the landfill pore spaces would presumably result in even less likelihood of an actual combustion event propagating through the waste mass.

In addition, on September 9, 2015, Bridgeton Landfill submitted a plan to address isolated "hot spots" that may occur in the North Quarry independent of the SSE occurring in the South Quarry (see Attachment J).

- Potential impacts to the EVOH capping material and landfill gas wellfield and piping should combustion occur at higher temperatures than in the South Quarry.

Response:

The impact of temperatures higher than those occurring in the South Quarry would require replacement of gas wells using gas well casings that have greater resistance to

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deformation from elevated temperatures than provided by the HDPE piping currently in place. All above ground piping would behave as it currently does in the South Quarry as would the EVOH or other temporary membrane material that could be deployed. The differences in useable life of the membrane due to slightly higher temperatures associated with higher temperatures within the waste mass may result in replacement of sections of the cap at some time, but would not significantly change the outcomes.

In the event of actual combustion, please see the response to the previous comment.

- It is unclear if consideration was given to the potential for displacement of waste material and slope movements which could allow shifting of radiologically-impacted material in the North Quarry as the waste mass is reduced.

Response:

As previously discussed, there is no basis to conclude that RIM is present in the North Quarry portion of the Bridgeton Landfill. Radionuclides detected during the Phase 1 investigation occurred within the Area 1 waste materials located beneath the northern extension of the North Quarry portion of the West Lake Landfill, not within the North Quarry.

All of the encountered radiologically impacted material is well below the ground surface below the North Quarry fill. As such, changes to the location of the RIM may occur vertically if the waste mass in which the RIM is contained were to undergo alteration due to heat and settlement takes place. The South Quarry experience has demonstrated that significant settlement of waste material can occur at this site with no instability, save for very shallow slumping such has occurred on the south slope due to interaction between the perimeter drainage system and the steeper slopes to the outside. There is no realistic expectation that significant heating or settlement would result in instability in the North Quarry or in the underlying Area 1 waste mass where RIM is present, given that the ground slopes are flatter and the depth of waste is significantly lower, resulting in less settlement potential than exists in the South Quarry.

In addition, no RIM was encountered in any areas below the North Quarry that are at, above, or proximate to the surrounding ground surface. Therefore, the possibility of such shifting as suggested by the comment to result in any increased potential for exposure or release was not considered as an issue that needed to be addressed, other than to conclude that such a scenario is highly implausible.

- Variability in the rate of movement of the subsurface fire has been a continuing issue. The movement rate assumed in the analysis appears to use current South

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Quarry measurements rather than maximum rates previously seen in the South Quarry. Any analysis designed to address a North Quarry fire must consider that the rate of movement could be at least as high as the fastest rate previously calculated for the South Quarry. Previous measurements have set that rate at 2.8 to 3.0 feet per day.

Response:

The movement of the heat front from the chemical reaction (there has been no documented evidence of a fire) should not be considered an issue. The rate of movement has been documented based on those locations that had not previously been warmed. This rate has not exceeded 15 feet per month since the measurements began. Conservative estimates of movement were made in late 2012 based on far less accurate measures of 18 feet per month. Bridgeton has never estimated the maximum rate of movement into new areas at the rate provided by the commenter.

Regardless, the proposed heat removal process is flexible in the amount of energy flux it can manage. Please see the response to comment bullet point one in this series of comments.

Missouri Department of Health and Senior Services Comments

1. Attachment A: Radon Flux Analysis for Isolation Barrier Alternatives Analysis

Attachment A, providing for radon flux estimates in the event a subsurface smoldering event (SSE) occurs, utilizes formula or model inputs that are outdated. The software package RAECOM, provided by World Information Service on Energy (WISE), is used in this document to estimate radon flux in the event of an SSE.

The U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research provides the regulatory guide *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers,* June 1989. This guidance appears to be the foundation for RAECOM. The International Atomic Energy Agency (IAEA) published Technical Reports Series number 474, *Measurement and Calculation of Radon Releases from NORM Residues*, 2013. This document provides updates on modeling radon emanation and exhalation from milling residues.

DHSS recommends that RAECOM calculation and modeling assumptions be appraised against the IAEA updates, to determine if RAECOM is sufficiently protective of human health. In support of the updated RAECOM results, Argonne National Laboratory's RESRAD Offsite software should be used as an additional line of evidence to confirm the

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findings of the RAECOM modeling. The more stringent of the findings should be used for decision making.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

We have compared the guidance contained in the IAEA document with the parameters and assumptions used in the RAECOM software. While the IAEA document did contain newer types of coverings (geotextile, etc.), the assumptions and parameters used to calculate radon flux were essentially the same as those used in the RAECOM model.

RESRAD Offsite does not provide radon fluxes as part of its output. This information is provided in the "Detailed.rep" file generated by RESRAD Onsite. Using the same numerical values as were used in the RAECOM simulation, the RESRAD Onsite radon flux values were calculated to be within a factor of two, but higher than the RAECOM-generated radon flux values.

Regardless of the model used, all models pose some level of uncertainty. Due to this uncertainty, in the event an SSE occurs in the radiologically-impacted material (RIM), DHSS recommends that environmental samples be collected to determine if levels of radon and its progeny pose unacceptable risk to workers and the public.

Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

Pursuant to the Administrative Settlement Agreement and Order on Consent for Removal Action – Preconstruction Work, a perimeter air monitoring network has been installed around both Areas 1 and 2 and is now operational. Monitoring of these stations includes collection of radon samples. These data can be used to evaluate potential exposure levels to onsite workers and along the property boundary where public exposure may occur.

2. Attachment A, Figure 2-2, Average Radon Flux from Area 1 for Four Scenarios

This figure identifies a radon flux rate of 0.29 picocuries per meter squared per second ($pCi/m^2/s$) for the "ROD Remedy with SSE". However, the document does not provide calculations to support the assumptions. DHSS recommends reviewing comment 1 above, updating RAECOM as recommended, and presenting the additional line of evidence using RESRAD Offsite. These results should be reviewed by the Missouri Department of Natural Resources and/or DHSS prior to finalizing. Again, DHSS recommends collection of environmental samples to determine if the outcome is protective of human health.

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Response: *Please note that the following response was previously provided to EPA on June 9, 2015 and has not been modified subsequent to that submittal.*

The basis for this value is presented in Section 3.5 of Attachment A. We will include a reference to the location of the calculations that support the table values. Please also see the response to Comment No. 1 above.

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Attachments

A. GIW-4 Schematic
B. Heat Extraction Calculation Spreadsheet
C. Expanded Heat Removal Pilot Study Initial Report
D. Cooler Specifications
E. Glycol Material Safety Data Sheet
F. Google Earth Historical Aerial Photographs from March and November 2002
G. Revised Drawing Sheet No. 16
H. August 2013 Heat Flux Calculations
I. Bird Management and Control Plans
J. Evaluation of Remedial Action Approaches for Hot Spot Removal, Bridgeton Landfill

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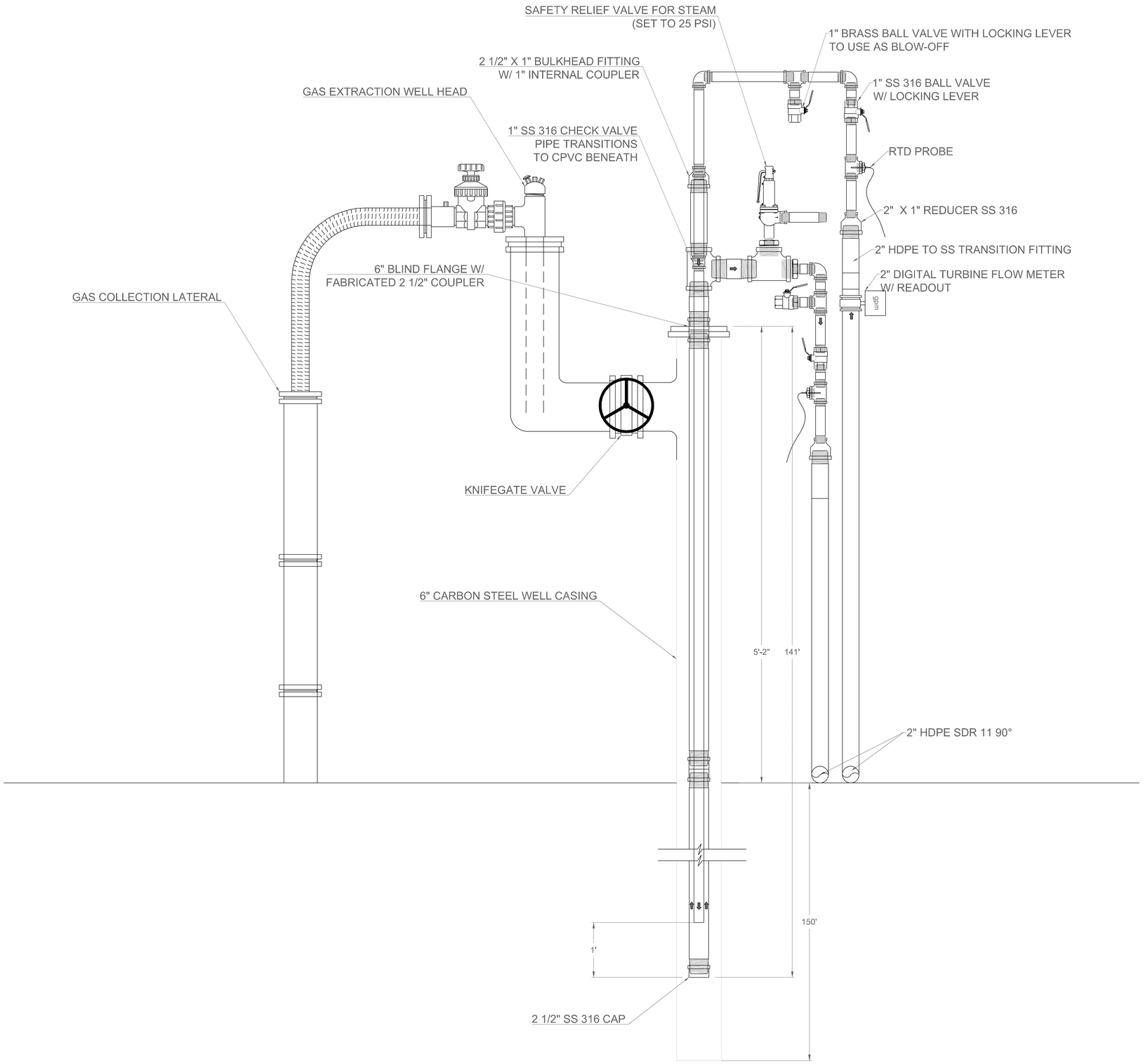
Attachment A:

GIW-4 Schematic



1 GIW-4 (MODIFIED FOR HEAT REMOVAL)

000 NTS

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL COOLING WELL INSTALLATION RECORD DRAWING	FEEZOR ENGINEERING, INC. Engineering for a Better World	SEPTEMBER 2013 DESIGNED BY: BJV APPROVED BY: ALK	DRAWING NO.: 000
GIW-4 **MODIFIED FOR HEAT REMOVAL**				
PROJECT NUMBER: BT-016	FILE PATH: C:\Users\Brad Vliet\Desktop\BT-016\V WORKING\GIW Enhancements (Option 4)\Construction Drawings\Alternative Heat Extraction\GIW#4 Alt-Build.dwg		REVISION	DATE

Attachment B:

Heat Extraction Calculation Spreadsheet

Establish the connection between Resistance Reading and Temperature based on the use a 3 factor equation linearize within the zone of interest

$$fit := line\left(\frac{R}{ohm}, \frac{Temperature}{K}\right) = \begin{pmatrix} -12.831 \\ 2.599 \end{pmatrix} \qquad stderr\left(\frac{R}{ohm}, \frac{Temperature}{K}\right) = 0.014$$

$$Resist := 138.505$$

$$T := fit_1 + fit_2 \cdot Resist - 273.15$$

$$T = 99.684$$

$$slope\left(\frac{Temperature}{K}, \frac{R}{\Omega}\right) = 0.38473 \qquad \frac{38.505}{100} = 0.385$$

total heat removal

rate of removal is equal to the rate of mass flow x the temperature difference

the total heat removed is equal to the integration of the rate, this is presuming the materials on above ground between the inlet and outlet temperature measuring devices are not affected.

where t is in degrees C

$$a := \begin{pmatrix} 3.983035 \\ 301.797 \\ 522528.9 \\ 69.34881 \\ 999.797950 \end{pmatrix}$$

the variation in density over the range of interest is

$$t_1 := 15 \qquad t_2 := 65$$

$$t = \begin{pmatrix} 15 \\ 65 \end{pmatrix}$$

$$\rho_w := -a_5 \cdot 1 - \frac{t - a_1 \cdot (t - a_2)^2}{a_3 \cdot t - a_4} \, kg \cdot m^{-3}$$

$\rho_w := 998.926 \frac{kg}{980.349\ m^3}$ $\frac{\rho_{w_2}}{\rho_{w_1}} = 0.981$ or within 2% this is good enough and we can use a mass density of say 990 kg/m^3 as a consistent value

$\rho_w := 990 \frac{kg}{m^3}$

$i := 1..147$

FR := READEXCEL("GIW-4_data.xlsx"; "U14:U180"; 1)

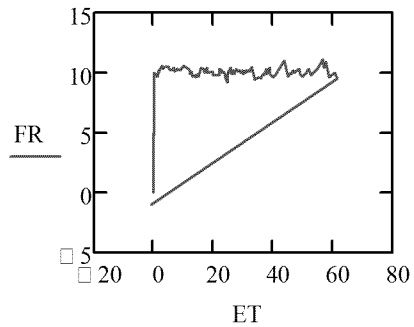
R_{in} := READEXCEL("GIW-4_data.xlsx"; "G14:G180"; 1)

R_{out} := READEXCEL("GIW-4_data.xlsx"; "N14:N180"; 1)

$Res_{in_i} := R_{in_i}$

ET := READEXCEL("GIW-4_data.xlsx"; "V14:V180"; 1)

$Res_{out_i} := R_{out_i}$



$C_p := 4.182 \frac{joule}{gm \cdot K}$ $\rho_w = 990 \frac{kg}{m^3}$

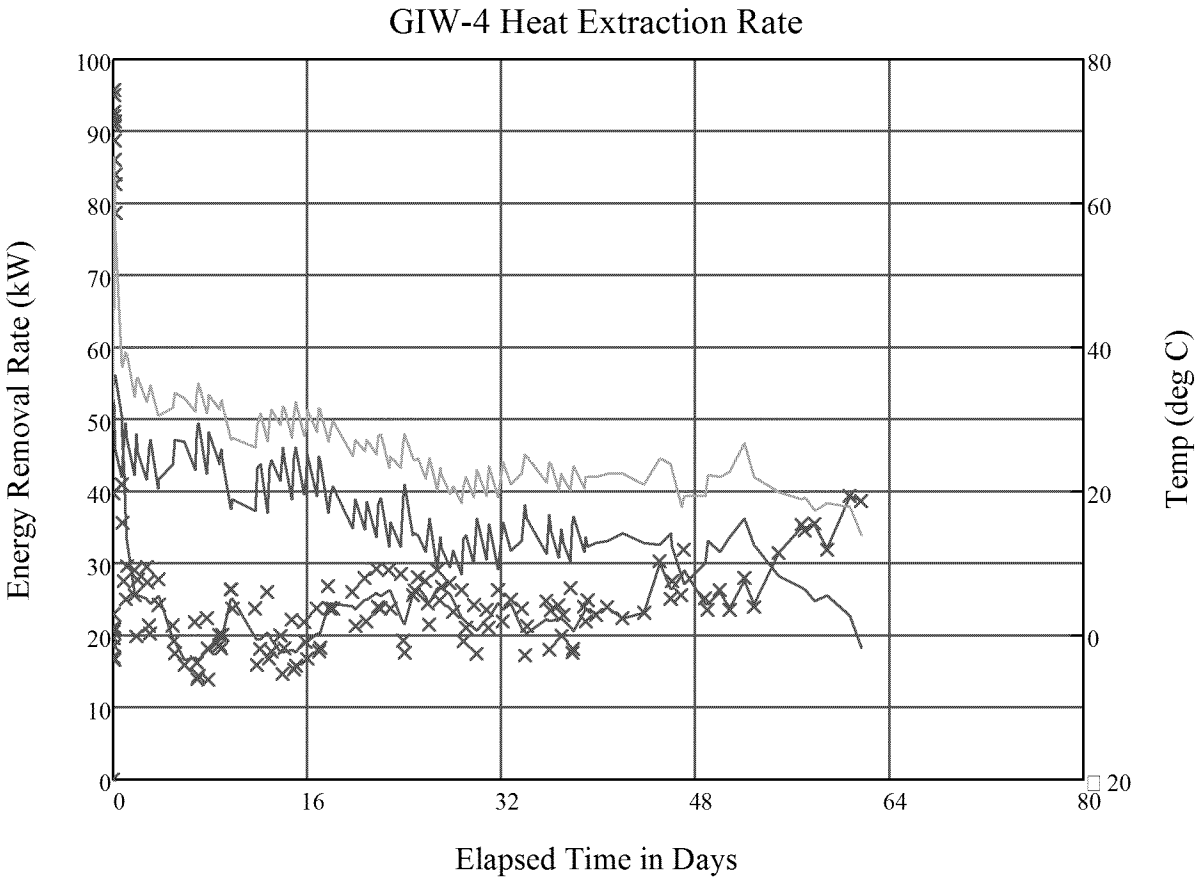
$T_{in_i} := fit_1 + fit_2 \cdot Res_{in_i} \cdot K$ $T_{out_i} := fit_1 + fit_2 \cdot Res_{out_i} \cdot K$ $Flow_i := FR_i \cdot gpm$

$ElapsedTime_i := ET_i \cdot day$

$10gpm \cdot \rho_w = 37.476kg \cdot \frac{1}{min}$

$EnergyRate_i := C_p \cdot \rho_w \cdot Flow_i \cdot (T_{out_i} - T_{in_i})$

smoothER := ksmooth(ElapsedTime, EnergyRate, 24hr)



Colder temperatures have resulted in an decrease in the water temp entering the system and a subsequent increase in the extraction rate since mid November

using implicit values the approximate total energy removed is

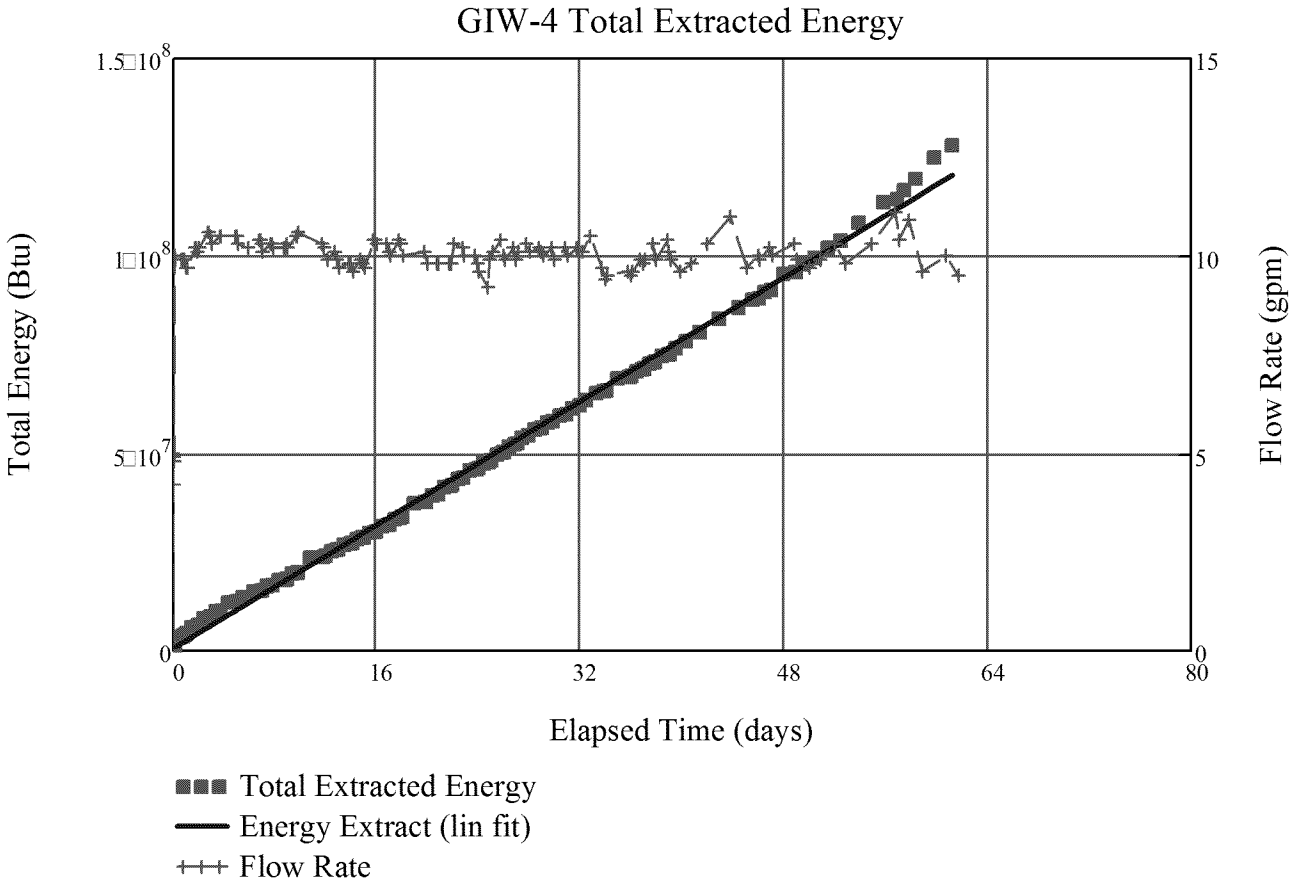
$n := 1 .. 146$

summation of the average rate of removal times the elapsed time delta

$$TotalEnergy_n := \sum_{i=1}^{n} \frac{EnergyRate_{i-1} + EnergyRate_i}{2} \cdot (ElapsedTime_i - ElapsedTime_{i-1})$$

$Slope := slope\left(\frac{ETIME_{energy}}{day}, \frac{TotalEnergy}{Btu}\right) = 1.958 \cdot 10^{6}$ gives the average slope of the energy removal line in btu per day

$Linearfit := \begin{pmatrix} linfit_1 \\ linfit_2 \end{pmatrix} \frac{ETIME_{energy}}{day} \cdot Btu$ plotted below as a black line



$TotalEnergy_{146} = 1.28 \cdot 10^{8} \cdot Btu$

$TotalEnergy_{146} = 37.511 \cdot MW \cdot hr$

$C_p = 4.182 \cdot 10^{3} \frac{joule}{kg \cdot K}$ $\rho_w = 990 \frac{kg}{m^3}$

It would appear the first 4 to 5 hours was the time needed to deplete energy within the well and gravel pack zone. As can be seen in the graph above the extraction rate has been very steady on average. The temperature in the well has dropped during the process

GIW-4
Database for Calculations

Interpolation Based upon Omega Table for PT385 RTD																					
	Temp deg C	Ohms																			
Pt 385	0	100																			
	100	138.505																			
GIW-4																					
138																					
			Incoming Water RTD							Outgoing Water RTD											
Measurement Device	Date and Time	Time	Positive to Ground Ohms	Negative to Ground Ohms	Positive to Negative Ohms	Positive to Ground Corrected Ohms	Negative to Ground Corrected Ohms	Positive to Ground Temperature (Deg F)	Negative to Ground Temperature (Deg F)	Positive to Ground Ohms	Negative to Ground Ohms	Positive to Negative Ohms	Positive to Ground Corrected Ohms	Negative to Ground Corrected Ohms	Positive to Ground Temperature (Deg F)	Negative to Ground Temperature (Deg F)	62' ThermoCouple Temperature (Deg F)	102' ThermoCouple Temperature (Deg F)	137' ThermoCouple Temperature (Deg F)	Flow Reading Gal/Min	Days Elapsed time
	9/26/2013	11:00 AM	110.00	110.00	0.60	109.40	109.40	75.94	75.94	110.00	110.00	0.60	109.40	109.40	75.94	75.94					
						0.00	0.00	-435.47	-435.47				0.00	0.00	-435.47	-435.47					
	9/26/2013-14:20		113.20	113.20	0.60	112.60	112.60	90.90	90.90	113.30	113.40	0.60	112.70	112.80	91.37	91.84	179.5	183.8	180.8	0	0
	9/26/2013-14:44		112.40	112.40	0.60	111.80	111.80	87.16	87.16	124.10	124.00	0.60	123.50	123.40	141.86	141.39	176	177.3	137.8	5	0.02
	9/26/2013-14:51		112.70	112.70	0.60	112.10	112.10	88.56	88.56	120.00	119.90	0.60	119.40	119.30	122.69	122.22	175.2	176	137.3	4.2	0.02
	9/26/2013-14:56		112.80	112.90	0.60	112.20	112.30	89.03	89.50	119.70	119.70	0.60	119.10	119.10	121.29	121.29	174.4	174.7	136.2	4.9	0.03
	9/26/2013-15:02		113.10	113.10	0.60	112.50	112.50	90.43	90.43	119.00	119.00	0.60	118.40	118.40	118.01	118.01	173.9	174.1	135.2	4.9	0.03
	9/26/2013-15:11		113.30	113.30	0.60	112.70	112.70	91.37	91.37	118.40	118.50	0.60	117.80	117.90	115.21	115.68	172.4	172.3	134.6	4.9	0.04
	9/26/2013-15:26		113.30	113.30	0.60	112.70	112.70	91.37	91.37	119.60	119.50	0.60	119.00	118.90	120.82	120.35	171.5	171	134.7	4.8	0.05
	9/26/2013-15:41		113.10	113.10	0.60	112.50	112.50	90.43	90.43	119.50	119.50	0.60	118.90	118.90	120.35	120.35	169.7	168.8	133	4.8	0.06
	9/26/2013-15:56		113.00	113.00	0.60	112.40	112.40	89.97	89.97	118.70	118.70	0.60	118.10	118.10	116.61	116.61	168.4	167.1	132.7	4.8	0.07
	9/26/2013-16:11		113.10	113.10	0.60	112.50	112.50	90.43	90.43	118.20	118.20	0.60	117.60	117.60	114.28	114.28	167	165.6	131	4.8	0.08
	9/26/2013-16:26		112.90	112.90	0.60	112.30	112.30	89.50	89.50	119.40	119.40	0.60	118.80	118.80	119.88	119.88	165.3	163.8	130.3	4.8	0.09
	9/26/2013-16:45		112.30	112.30	0.60	111.70	111.70	86.69	86.69	126.30	126.30	0.60	125.70	125.70	152.14	152.14	161.4	158.9	118	10	0.10
	9/26/2013-16:50		112.10	112.10	0.60	111.50	111.50	85.76	85.76	126.20	126.20	0.60	125.60	125.60	151.67	151.67	160.2	157.6	116	10	0.10
	9/26/2013-16:55		111.90	111.90	0.60	111.30	111.30	84.82	84.82	125.70	125.70	0.60	125.10	125.10	149.34	149.34	159.1	156.4	114.7	9.9	0.11
	9/26/2013-17:00		111.90	111.90	0.60	111.30	111.30	84.82	84.82	125.60	125.60	0.60	125.00	125.00	148.87	148.87	158.1	155.2	113.3	9.9	0.11
	9/26/2013-17:05		111.80	111.80	0.60	111.20	111.20	84.36	84.36	125.30	125.30	0.60	124.70	124.70	147.47	147.47	158	154.2	112.3	9.9	0.11
	9/26/2013-17:10		111.70	111.70	0.60	111.10	111.10	83.89	83.89	125.30	125.30	0.60	124.70	124.70	147.47	147.47	156.9	153.2	110.6	9.9	0.12
	9/26/2013-17:15		111.70	111.70	0.60	111.10	111.10	83.89	83.89	125.20	125.20	0.60	124.60	124.60	147.00	147.00	156.1	152.1	109.9	9.9	0.12
	9/26/2013-17:30		111.50	111.50	0.60	110.90	110.90	82.95	82.95	124.70	124.70	0.60	124.10	124.10	144.66	144.66	152.6	149.1	110.7	9.9	0.13
	9/26/2013-17:45		111.40	111.40	0.60	110.80	110.80	82.49	82.49	124.20	124.20	0.60	123.60	123.60	142.32	142.32	149.7	146.1	109.3	9.9	0.14
	9/26/2013-18:00		111.20	111.20	0.60	110.60	110.60	81.55	81.55	123.70	123.70	0.60	123.10	123.10	139.99	139.99	147.7	143.9	107.8	9.9	0.15
	9/26/2013-18:15		111.10	111.10	0.60	110.50	110.50	81.08	81.08	123.40	123.40	0.60	122.80	122.80	138.58	138.58	145.7	141.9	106.8	9.9	0.16
	9/26/2013-18:53		110.70	110.70	0.60	110.10	110.10	79.21	79.21	122.40	122.40	0.60	121.80	121.80	133.91	133.91	141.1	137.3	104.5	9.9	0.19
	9/27/2013-6:52		109.20	109.20	0.60	108.60	108.60	72.20	72.20	115.30	115.30	0.60	114.70	114.70	100.72	100.72	104.2	102.9	90.4	9.9	0.69
	9/27/2013-8:40		109.80	109.80	0.60	109.20	109.20	75.01	75.01	115.10	115.10	0.60	114.50	114.50	99.78	99.78	101.8	101	91	9.9	0.76
	9/27/2013-11:33		111.40	111.40	0.60	110.80	110.80	82.49	82.49	115.50	115.50	0.60	114.90	114.90	101.65	101.65	103.3	103.1	97.1	9.9	0.88
	9/27/2013-14:42		112.10	112.10	0.60	111.50	111.50	85.76	85.76	115.90	115.90	0.60	115.30	115.30	103.52	103.52	104.1	104.4	98.9	9.7	1.02
	9/27/2013-17:28		111.30	111.30	0.60	110.70	110.70	82.02	82.02	115.80	115.80	0.60	115.20	115.20	103.06	103.06	105	105.1	98	9.7	1.13
	9/28/2013-8:07		109.30	109.30	0.60	108.70	108.70	72.67	72.67	113.50	113.50	0.60	112.90	112.90	92.30	92.30	95.7	96	89.9	10.2	1.74
	9/28/2013-9:05		110.00	110.00	0.60	109.40	109.40	75.94	75.94	113.70	113.70	0.60	113.10	113.10	93.24	93.24	95.6	96.1	91.2	10.2	1.78
	9/28/2013-12:12		111.50	111.50	0.60	110.90	110.90	82.95	82.95	114.40	114.40	0.60	113.80	113.80	96.51	96.51	97.3	98.3	96.5	10.1	1.91
	9/28/2013-15:07		110.50	110.50	0.60	109.90	109.90	78.28	78.28	114.50	114.50	0.60	113.90	113.90	96.98	96.98	99.2	100	94	10.2	2.03
	9/29/2013-8:31		109.10	109.10	0.60	108.50	108.50	71.74	71.74	113.20	113.20	0.60	112.60	112.60	90.90	90.90	93.3	92.9	88.5	10.6	2.76
	9/29/2013-9:30		109.50	109.50	0.60	108.90	108.90	73.60	73.60	113.30	113.30	0.60	112.70	112.70	91.37	91.37	92.8	92.9	89.3	10.6	2.80
	9/29/2013-12:30		110.80	110.80	0.60	110.20	110.20	79.68	79.68	113.80	113.80	0.60	113.20	113.20	93.71	93.71	93.4	94.1	92.7	10.5	2.92
	9/29/2013-15:28		111.20	111.20	0.60	110.60	110.60	81.55	81.55	114.10	114.10	0.60	113.50	113.50	95.11	95.11	96	96.9	95.1	10.3	3.05
	9/30/2013-7:28		108.60	108.60	0.60	108.00	108.00	69.40	69.40	112.50	112.50	0.60	111.90	111.90	87.63	87.63	90.3	90.8	86.6	10.5	3.71
	9/30/2013-8:36		109.10	109.10	0.60	108.50	108.50	71.74	71.74	112.50	112.50	0.60	111.90	111.90	87.63	87.63	90	90.6	87.7	10.5	3.76
	10/1/2013-11:41		109.90	109.90	0.60	109.30	109.30	75.47	75.47	112.90	112.90	0.60	112.30	112.30	89.50	89.50	90.9	91.8	90.3	10.5	4.80
	10/1/2013-14:25		110.70	110.70	0.60	110.10	110.10	79.21	79.21	113.40	113.40	0.60	112.80	112.80	91.84	91.84	91.8	92.9	92	10.5	5.00
	10/1/2013-16:29		111.20	111.20	0.60	110.60	110.60	81.55	81.55	113.70	113.70	0.60	113.10	113.10	93.24	93.24	93.5	94.7	94.8	10.3	5.09
	10/2/2013-11:35		111.10	111.10	0.60	110.50	110.50	81.08	81.08	113.40	113.40	0.60	112.80	112.80	91.84	91.84	91.9	92.2	89.9	10.2	5.89
	10/3/2013-8:01		109.60	109.60	0.60	109.00	109.00	74.07	74.07	112.70	112.70	0.60	112.10	112.10	88.56	88.56	91.8	92.7	90.4	10.4	6.74
	10/3/2013-11:12		111.30	111.30	0.60	110.70	110.70	82.02	82.02	113.60	113.60	0.60	113.00	113.00	92.77	92.77	92.7	94	94.6	10.4	6.87
	10/3/2013-13:04		112.00	112.00	0.60	111.40	111.40	85.29	85.29	114.00	114.00	0.60	113.40	113.40	94.64	94.64	94.5	96	97.1	10.3	6.95
	10/3/2013-14:50		112.10	112.10	0.60	111.50	111.50	85.76	85.76	114.20	114.20	0.60	113.60	113.60	95.58	95.58	96.9	98.5	99.4	10.1	7.02
	10/4/2013-7:08		109.40	109.40	0.60	108.80	108.80	73.14	73.14	112.60	112.60	0.60	112.00	112.00	88.10	88.10	92.9	93.9	91.6	10.3	7.70
	10/4/2013-9:03		110.40	110.40	0.60	109.80	109.80	77.81	77.81	113.00	113.00	0.60	112.40	112.40	89.97	89.97	92.3	93.6	93.3	10.3	7.78
	10/4/2013-11:05		111.60	111.60	0.60	111.00	111.00	83.42	83.42	113.60	113.60	0.60	113.00	113.00	92.77	92.77	94	95.5	96.7	10.2	7.86
	10/5/2013-7:58		109.90	109.90	0.60	109.30	109.30	75.47	75.47	112.80	112.80	0.60	112.20	112.20	89.03	89.03	94.2	95.7	94.2	10.2	8.73
	10/5/2013-9:03		110.30	110.30	0.60	109.70	109.70	77.34	77.34	113.00	113.00	0.60	112.40	112.40	89.97	89.97	94.2	95.8	94.9	10.2	8.78
	10/5/2013-12:00		110.70	110.70	0.60	110.10	110.10	79.21	79.21	113.30	113.30	0.60	112.70	112.70	91.37	91.37	95.4	97.1	96.7	10.3	8.90
	10/5/2013-13:57		110.20	110.20	0.60	109.60	109.60	76.88	76.88	113.10	113.10	0.60	112.50	112.50	90.43	90.43	95.1	96.7	95.4	10.2	8.98
	10/6/2013-6:39		107.60	107.60	0.60	107.00	107.00	64.72	64.72	111.30	111.30	0.60	110.70	110.70	82.02	82.02	90.2	91.8	88.8	10.5	9.68
	10/6/2013-7:47		107.50	107.50	0.60	106.90	106.90	64.26	64.26	111.20	111.20	0.60	110.60	110.60	81.55	81.55	89.6	91.3	88.4	10.5	9.73
	10/6/2013-10:06		108.00	108.00	0.60	107.40	107.40	66.59	66.59	111.30	111.30	0.60	110.70	110.70	82.02	82.02	89.5	91.3	90	10.6	9.82
	10/8/2013-7:28		107.40	107.40	0.60	106.80	106.80	63.79	63.79	110.80	110.80	0.60	110.20	110.20	79.68	79.68	86.5	88.4	96.5	10.3	11.71
	10/8/2013-10:56		109.70	109.70	0.60	109.10	109.10	74.54	74.54	112.00	112.00	0.60	111.40	111.40	85.29	85.29	87.1	89.1	90.9	10.2	11.86
	10/8/2013-17:13		109.90	109.90	0.60	109.30	109.30	75.47	75.47	112.60	112.60	0.60	112.00	112.00	88.10	88.10	91.9	94	93.9	9.9	12.12
	10/9/2013-6:58		107.30	107.30	0.60	106.70	106.70	63.32	63.32	111.10	111.10	0.60	110.50	110.50	81.08	81.08	87.3	88.4	86	10.1	12.69
	10/9/2013-11:21		109.70	109.70	0.60	109.10	109.10	74.54	74.54	112.20	112.20	0.60	111.60	111.60	86.23	86.23	87.4	88.9	90.5	9.9	12.88
	10/9/2013-15:33		110.10	110.10	0.60	109.50	109.50	76.41	76.41	112.80	112.80	0.60	112.20	112.20	89.03	89.03	92.3	94.1	94.7	9.7	13.05
	10/10/2013-9:22		109.00	109.00	0.60	108.40	108.40	71.27	71.27	112.00	112.00	0.60	111.40	111.40	85.29	85.29	88.7	89.8	89.6	9.8	13.79
	10/10/2013-13:48		110.80	110.80	0.60	110.20	110.20	79.68	79.68	113.00	113.00	0.60	112.40	112.40	89.97	89.97	91.2	92.8	94.9	9.8	13.98
	10/10/2013-17:36		110.00	110.00	0.60	109.40	109.40	75.94	75.94	112.80	112.80	0.60	112.20	112.20	89.03	89.03	93.2	94.6	94.5	9.6	14.14
	10/11/2013-7:48		108.00	108.00	0.60	107.40	107.40	66.59	66.59	111.30	111.30	0.60	110.70	110.70	82.02	82.02	89.1	90.1	88.5	9.9	14.73
	10/11/2013-11:43		110.20	110.20	0.60	109.60	109.60	76.88	76.88	112.50	112.50	0.60	111.90	111.90	87.63	87.63	90.7	92.3	94.2	9.8	14.89
	10/11/2013-15:46		110.80	110.80	0.60	110.20	110.20	79.68	79.68	113.20	113.20	0.60	112.60	112.60	90.90	90.90	94	95.7	97.3	9.7	15.06
	10/12/2013-8:10		108.30	108.30	0.60	107.70	107.70	68.00	68.00	111.40	111.40	0.60	110.80	110.80	82.49	82.49	89.7	90.5	89.7	10.4	15.74
	10/12/2013-11:14		109.10	109.10	0.60	108.50	108.50	71.74	71.74	111.80	111.80	0.60	111.20	111.20	84.36	84.36	89.8	90.9	91	10.4	15.87
	10/12/2013-14:23		110.40	110.40	0.60	109.80	109.80	77.81	77.81	112.80	112.80	0.60	112.20	112.20	89.03	89.03	91.5	93	94.7	10.3	16.00
	10/13/2013-9:04		108.20	108.20	0.60	107.60	107.60	67.53	67.53	111.60	111.60	0.60	111.00	111.00	83.42	83.42	89.2	89.7	93.6	10.3	16.78
	10/13/2013-13:33		110.30	110.30	0.60	109.70	109.70	77.34	77.34	112.90	112.90	0.60	112.30	112.30	89.50	89.50	92.8	93.3	93.5	10.1	16.97
	10/13/2013-16:11		110.10	110.10	0.60	109.50	109.50	76.41	76.41	112.80	112.80	0.60	112.20	112.20	89.03	89.03	94.7	94.5	93.9	10	17.08
	10/14/2013-7:32		107.30	107.30	0.60	106.70	106.70	63.32	63.32	111.10	111.10	0.60	110.50	110.50	81.08	81.08	89.2	87.6	84.2	10.4	17.72
	10/14/2013-11:22		108.20	108.20	0.60	107.60	107.60	67.53	67.53	111.60	111.60	0.60	111.00	111.00	83.42	83.42	89.6	88.3	89	10.3	17.88
	10/14/2013-16:45		108.70	108.70	0.60	108.10	108.10	69.87	69.87	112.20	112.20	0.60	111.60	111.60	86.23	86.23	90.3	90.8	95.2	10	18.10
	10/16/2013-7:45		106.50	106.50	0.60	105.90	105.90	59.58	59.58	110.30	110.30	0.60	109.70	109.70	77.34	77.34	83.2	83.5	82.7	10.1	19.73
	10/16/2013-13:48		108.00	108.00	0.60	107.40	107.40	66.59	66.59	111.20	111.20	0.60	110.60	110.60	81.55	81.55	84.6	85.4	86.5	9.8	19.98
	10/17/2013-7:56		106.40	106.40	0.60	105.80	105.80	59.11	59.11	110.60	110.60	0.60	110.00	110.00	78.75	78.75	82.4	83	86.8	9.8	20.73
	10/17/2013-11:13		107.90	107.90	0.60	107.30	107.30	66.13	66.13	111.20	111.20	0.60	110.60	110.60	81.55	81.55	81.7	82.4	83.9	9.8	20.87
	10/18/2013-7:15		106.00	106.00	0.60	105.40	105.40	57.24	57.24	110.40	110.40	0.60	109.80	109.80	77.81	77.81	82.5	82.1	80.7	9.8	21.70
	10/18/2013-10:52		107.80	107.80	0.60	107.20	107.20	65.66	65.66	111.40	111.40	0.60	110.80	110.80	82.49	82.49	83.8	85.1	91.1	9.8	21.86
	10/18/2013-15:23		108.10	108.10	0.60	107.50	107.50	67.06	67.06	111.50	111.50	0.60	110.90	110.90	82.95	82.95	84.8	86	89.8	10.3	22.04
	10/19/2013-8:07		105.50	105.50	0.60	104.90	104.90	54.91	54.91	109.70	109.70	0.60	109.10	109.10	74.54	74.54	79.8	79.5	77.9	10.2	22.74
	10/19/2013-11:22		106.80	106.80	0.60	106.20	106.20	60.98	60.98	110.30	110.30	0.60	109.70	109.70	77.34	77.34	80	80.7	83	10	22.88
	10/20/2013-7:43		105.50	105.50	0.60	104.90	104.90	54.91	54.91	109.70	109.70	0.60	109.10	109.10	74.54	74.54	79.8	79.6	76.7	10	23.72
	10/20/2013-12:25		108.20	108.20	0.60	107.60	107.60	67.53	67.53	111.10	111.10	0.60	110.50	110.50	81.08	81.08	81.6	82.9	82.6	9.8	23.92
	10/20/2013-14:51		108.80	108.80	0.60	108.20	108.20	70.33	70.33	111.50	111.50	0.60	110.90	110.90	82.95	82.95	84.2	85.4	85.7	9.6	24.02
	10/21/2013-7:54		106.10	106.10	0.60	105.50	105.50	57.71	57.71	110.20	110.20	0.60	109.60	109.60	76.88	76.88	80.8	80.9	77.1	9.2	24.73
	10/21/2013-10:51		106.20	106.20	0.60	105.60	105.60	58.18	58.18	110.10	110.10	0.60	109.50	109.50	76.41	76.41	80	80.5	77	9.9	24.85
	10/21/2013-17:35		106.10	106.10	0.60	105.50	105.50	57.71	57.71	110.20	110.20	0.60	109.60	109.60	76.88	76.88	81	81.8	82.6	10.1	25.14
	10/22/2013-8:05		105.20	105.20	0.60	104.60	104.60	53.50	53.50	109.10	109.10	0.60	108.50	108.50	71.74	71.74	76.3	76.9	75.5	10.4	25.74
	10/22/2013-13:01		106.10	106.10	0.60	105.50	105.50	57.71	57.71	109.70	109.70	0.60	109.10	109.10	74.54	74.54	77	78	75	10	25.95
	10/22/2013-16:12		107.00	107.00	0.60	106.40	106.40	61.92	61.92	110.20	110.20	0.60	109.60	109.60	76.88	76.88	78	79.6	83.5	9.9	26.08

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Interpolation Based upon Omega Table for PT385 RTD																				
	Temp deg C	Ohms																		
Pt 385	0	100																		
	100	138.505																		
GIW -4																				
138																				
			Incoming Water RTD							Outgoing Water RTD										
Measurement Device	Date and Time	Time	Positive to Ground Ohms	Negative to Ground Ohms	Positive to Negative Ohms	Positive to Ground Corrected Ohms	Negative to Ground Corrected Ohms	Positive to Ground Temperature (Deg F)	Negative to Ground Temperature (Deg F)	Positive to Ground Ohms	Negative to Ground Ohms	Positive to Negative Ohms	Positive to Ground Corrected Ohms	Negative to Ground Corrected Ohms	Positive to Ground Temperature (Deg F)	Negative to Ground Temperature (Deg F)	62' ThermoCouple Temperature (Deg F)	102' ThermoCouple Temperature (Deg F)	137' ThermoCouple Temperature (Deg F)	Flow Reading Gal/Min	Days Elapsed time
	10/23/2013-7:24		104.30	104.30	0.60	103.70	103.70	49.30	49.30	108.50	108.50	0.60	107.90	107.90	68.93	68.93	76.1	76.3	72.3	10.2	26.71
	10/23/2013-13:04		106.00	106.00	0.60	105.40	105.40	57.24	57.24	109.70	109.70	0.60	109.10	109.10	74.54	74.54	77.1	78.6	81.8	9.9	26.95
	10/23/2013-16:50		105.40	105.40	0.60	104.80	104.80	54.44	54.44	109.30	109.30	0.60	108.70	108.70	72.67	72.67	77.4	78.9	80.9	10.1	27.10
	10/24/2013-7:50		104.40	104.40	0.60	103.80	103.80	49.76	49.76	108.30	108.30	0.60	107.70	107.70	68.00	68.00	75.8	76.4	72.4	10.3	27.73
	10/24/2013-15:19		105.30	105.30	0.60	104.70	104.70	53.97	53.97	108.70	108.70	0.60	108.10	108.10	69.87	69.87	76.9	78	75.4	10.1	28.04
	10/25/2013-8:02		104.00	104.00	0.60	103.40	103.40	47.89	47.89	107.80	107.80	0.60	107.20	107.20	65.66	65.66	71.9	72.2	69	10.2	28.74
	10/25/2013-11:24		105.90	105.90	0.60	105.30	105.30	56.78	56.78	108.70	108.70	0.60	108.10	108.10	69.87	69.87	72.5	73.7	72.9	10.1	28.88
	10/25/2013-16:18		106.10	106.10	0.60	105.50	105.50	57.71	57.71	109.20	109.20	0.60	108.60	108.60	72.20	72.20	76.5	77.3	76.2	10	29.08
	10/26/2013-8:07		104.60	104.60	0.60	104.00	104.00	50.70	50.70	108.10	108.10	0.60	107.50	107.50	67.06	67.06	72.7	73.3	71.1	10.2	29.74
	10/26/2013-13:18		107.00	107.00	0.60	106.40	106.40	61.92	61.92	109.60	109.60	0.60	109.00	109.00	74.07	74.07	75.6	77.4	79.2	9.9	29.96
	10/27/2013-9:00		104.80	104.80	0.60	104.20	104.20	51.63	51.63	108.20	108.20	0.60	107.60	107.60	67.53	67.53	71.3	72.8	73.4	10.2	30.78
	10/27/2013-13:49		106.70	106.70	0.60	106.10	106.10	60.52	60.52	109.80	109.80	0.60	109.20	109.20	75.01	75.01	74.8	76.8	79.8	10	30.98
	10/28/2013-7:35		104.30	104.30	0.60	103.70	103.70	49.30	49.30	108.10	108.10	0.60	107.50	107.50	67.06	67.06	72.1	73.7	73.3	10.2	31.72
	10/28/2013-17:51		106.80	106.80	0.60	106.20	106.20	60.98	60.98	110.00	110.00	0.60	109.40	109.40	75.94	75.94	78.4	80.4	81.5	10.1	32.15
	10/29/2013-9:06		105.30	105.30	0.60	104.70	104.70	53.97	53.97	108.80	108.80	0.60	108.20	108.20	70.33	70.33	74.7	76.4	76.8	10.5	32.78
	10/30/2013-7:09		105.80	105.80	0.60	105.20	105.20	56.31	56.31	109.40	109.40	0.60	108.80	108.80	73.14	73.14	76.1	77.9	78.1	9.7	33.70
	10/30/2013-13:22		107.70	107.70	0.60	107.10	107.10	65.19	65.19	110.40	110.40	0.60	109.80	109.80	77.81	77.81	78.9	81.2	83.5	9.4	33.96
	10/30/2013-17:15		107.00	107.00	0.60	106.40	106.40	61.92	61.92	110.30	110.30	0.60	109.70	109.70	77.34	77.34	79.7	81.9	82.3	9.5	34.12
	11/1/2013-7:34		105.10	105.10	0.60	104.50	104.50	53.04	53.04	108.90	108.90	0.60	108.30	108.30	70.80	70.80	76.4	78.1	77.4	9.6	35.72
	11/1/2013-13:37		107.20	107.20	0.60	106.60	106.60	62.85	62.85	110.00	110.00	0.60	109.40	109.40	75.94	75.94	78.7	81.1	82.7	9.5	35.97
	11/1/2013-16:54		106.30	106.30	0.60	105.70	105.70	58.65	58.65	109.90	109.90	0.60	109.30	109.30	75.47	75.47	79.1	81.1	80.5	9.6	36.11
	11/2/2013-7:16		104.90	104.90	0.60	104.30	104.30	52.10	52.10	108.50	108.50	0.60	107.90	107.90	68.93	68.93	75.6	77.4	76.4	9.9	36.71
	11/2/2013-13:23		106.40	106.40	0.60	105.80	105.80	59.11	59.11	109.40	109.40	0.60	108.80	108.80	73.14	73.14	77	79.1	80.4	9.8	36.96
	11/2/2013-16:43		105.70	105.70	0.60	105.10	105.10	55.84	55.84	109.10	109.10	0.60	108.50	108.50	71.74	71.74	77.2	79	78.1	9.9	37.10
	11/3/2013-7:22		104.70	104.70	0.60	104.10	104.10	51.17	51.17	108.50	108.50	0.60	107.90	107.90	68.93	68.93	73	74.6	73.9	10.3	37.71
	11/3/2013-10:51		106.70	106.70	0.60	106.10	106.10	60.52	60.52	109.30	109.30	0.60	108.70	108.70	72.67	72.67	75.1	77.2	79.2	10	37.85
	11/3/2013-13:02		107.10	107.10	0.60	106.50	106.50	62.39	62.39	109.80	109.80	0.60	109.20	109.20	75.01	75.01	77.2	79.5	81.2	9.9	37.95
	11/4/2013-10:11		105.20	105.20	0.60	104.60	104.60	53.50	53.50	108.60	108.60	0.60	108.00	108.00	69.40	69.40	74.4	76.1	75.6	10.4	38.83
	11/4/2013-13:39		106.00	106.00	0.60	105.40	105.40	57.24	57.24	109.20	109.20	0.60	108.60	108.60	72.20	72.20	74.7	76.7	77.3	10.1	38.97
	11/4/2013-17:17		105.50	105.50	0.60	104.90	104.90	54.91	54.91	109.20	109.20	0.60	108.60	108.60	72.20	72.20	75.8	77.6	76.6	9.9	39.12
	11/5/2013-10:07		105.70	105.70	0.60	105.10	105.10	55.84	55.84	109.20	109.20	0.60	108.60	108.60	72.20	72.20	75.3	77.1	76.7	9.6	39.82
	11/6/2013-8:05		105.80	105.80	0.60	105.20	105.20	56.31	56.31	109.40	109.40	0.60	108.80	108.80	73.14	73.14	76.7	78.7	77.9	9.8	40.74
	11/7/2013-14:09		106.20	106.20	0.60	105.60	105.60	58.18	58.18	109.40	109.40	0.60	108.80	108.80	73.14	73.14	75.7	78	78.7	10.3	41.99
	11/9/2013-8:51		105.70	105.70	0.60	105.10	105.10	55.84	55.84	108.80	108.80	0.60	108.20	108.20	70.33	70.33	73.9	75.9	76.7	11	43.77
	11/10/2013-16:03		105.60	105.60	0.60	105.00	105.00	55.37	55.37	110.20	110.20	0.60	109.60	109.60	76.88	76.88	78.9	80.9	79.7	9.7	45.07
	11/11/2013-13:30		106.20	106.20	0.60	105.60	105.60	58.18	58.18	109.90	109.90	0.60	109.30	109.30	75.47	75.47	77.9	80.1	80.4	10	45.97
	11/11/2013-16:16		105.50	105.50	0.60	104.90	104.90	54.91	54.91	109.60	109.60	0.60	109.00	109.00	74.07	74.07	78.5	80.6	79.5	9.9	46.08
	11/12/2013-10:32		103.90	103.90	0.60	103.30	103.30	47.43	47.43	107.60	107.60	0.60	107.00	107.00	64.72	64.72	70.4	72.3	72.1	10.2	46.84
	11/12/2013-16:01		103.50	103.50	0.60	102.90	102.90	45.56	45.56	108.20	108.20	0.60	107.60	107.60	67.53	67.53	73.5	75.3	73.4	10	47.07
	11/14/2013-9:49		104.60	104.60	0.60	104.00	104.00	50.70	50.70	108.20	108.20	0.60	107.60	107.60	67.53	67.53	72.1	74.4	75.9	10.3	48.81
	11/14/2013-14:52		105.80	105.80	0.60	105.20	105.20	56.31	56.31	109.30	109.30	0.60	108.70	108.70	72.67	72.67	74.6	77.5	77.5	9.9	49.02
	11/15/2013-15:00		105.20	105.20	0.60	104.60	104.60	53.50	53.50	109.20	109.20	0.60	108.60	108.60	72.20	72.20	76.2	78.8	79.3	9.7	50.03
	11/16/2013-10:30		106.00	106.00	0.60	105.40	105.40	57.24	57.24	109.50	109.50	0.60	108.90	108.90	73.60	73.60	75.3	77.9	79.6	9.9	50.84
	11/17/2013-15:30		107.00	107.00	0.60	106.40	106.40	61.92	61.92	111.00	111.00	0.60	110.40	110.40	80.62	80.62	84.1	87.1	87.4	10.3	52.05
	11/18/2013-10:18		105.60	105.60	0.60	105.00	105.00	55.37	55.37	109.20	109.20	0.60	108.60	108.60	72.20	72.20	76.8	79.4	80	9.8	52.83
	11/20/2013-11:34		103.90	103.90	0.60	103.30	103.30	47.43	47.43	108.40	108.40	0.60	107.80	107.80	68.46	68.46	73.3	75.7	76.1	10.3	54.88
	11/22/2013-8:51		103.30	103.30	0.60	102.70	102.70	44.62	44.62	108.00	108.00	0.60	107.40	107.40	66.59	66.59	73.4	75.7	74.9	11.1	56.77
	11/22/2013-15:28		103.20	103.20	0.60	102.60	102.60	44.15	44.15	108.10	108.10	0.60	107.50	107.50	67.06	67.06	73.8	76	75.2	10.4	57.05
	11/23/2013-10:25		102.60	102.60	0.60	102.00	102.00	41.35	41.35	107.40	107.40	0.60	106.80	106.80	63.79	63.79	73.6	75.3	74.5	10.9	57.84
	11/24/2013-10:59		102.90	102.90	0.60	102.30	102.30	42.75	42.75	107.80	107.80	0.60	107.20	107.20	65.66	65.66	69.9	71.8	72.8	9.6	58.86
	11/26/2013-7:33		101.80	101.80	0.60	101.20	101.20	37.61	37.61	107.60	107.60	0.60	107.00	107.00	64.72	64.72	70.5	71.8	70.3	10	60.72
	11/27/2013-7:13		100.10	100.10	0.60	99.50	99.50	29.66	29.66	106.10	106.10	0.60	105.50	105.50	57.71	57.71	66.6	67.8	65.5	9.5	61.70

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Attachment C:

Expanded Heat Removal Pilot Study Initial Report

TRADE SECRET - CONFIDENTIAL

ENGINEERING FOR A BETTER WORLD
FEEZOR
ENGINEERING, INC.

EXPANDED HEAT REMOVAL PILOT STUDY INITIAL REPORT

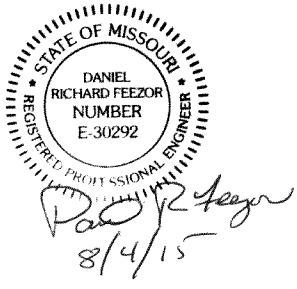
BRIDGETON LANDFILL

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

August 2015

Prepared For:

Bridgeton Landfill, LLC
13570 St. Charles Rock Road
Bridgeton, MO 63044



Prepared By:

Feezor Engineering, Inc.
3405 Hollenberg Drive
Bridgeton, MO 63044

In Association With:

P. J. Carey & Associates, P.C.
587 Valine Way
Sugar Hill, Georgia 30518

Initial Report
Expanded Heat Removal Pilot Study
Bridgeton Landfill, LLC

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1 INTRODUCTION

This document is being submitted to meet the requirements of Condition No. 2 of the September 4, 2014 Missouri Department of Natural Resources (MDNR) letter approving the Expanded Heat Removal Pilot Study in the South Quarry of the Bridgeton Landfill in Bridgeton, Missouri. As stated in the MDNR approval letter,

> *"Pilot projects for beneficial use are usually granted by the SWMP for a period not to exceed one year. Reports are received to evaluate the effectiveness of the project....The initial pilot project report must be submitted one month prior to the first anniversary of the date of this letter. The pilot project will be allowed to continue while the report is being reviewed."*

This report includes a summary of work completed and data collected since the approval of the Expanded Heat Removal Pilot Study through July 15, 2015. Also attached to this report are the Quarterly Update for the period 03/31/15 to 06/29/15 and the as-built details for a second expansion to the heat removal pilot study (GIW 8, -9, -11, -12, and -13.)

The data presented for the purpose of the initial pilot study report includes temperature profiles, heat removal graphs, a drawing of the heat removal points and associated thermocouple strands and the system operating log. **Appendix A** includes temperature profiles as measured in the Temperature Monitoring Probes (TMPs) for the initial report period. **Appendix B** includes graphs of the heat removal and corresponding flow rate for each removal point. **Appendix C** drawing presents the heat removal system and associated TMPs currently being operated and monitored. **Appendix D** includes the operating log for the system. The log was generated to record significant events related to the operation of the system.

2 SYSTEM OPERATION

The heat removal system is operated to deliver temperature treated liquid under pressure to each heat extraction point at a desired flow rate. An equalization tank and electric system pump are utilized to maintain pressurized liquid throughout the system.

The following is a summary of significant events that occurred during the initial reporting period:

- (October 24, 2014) Installation of U-Tube Heat Removal Points in GIW-2, -3, -4,-5,-6,-7 and -10 and consistent operation began.
- (February 14, 2015) Completed the conversion from the open cooling tower using treated city water to the closed loop cooling tower using propylene-glycol as the heat transfer medium.

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- (June 30, 2015) Pipe within pipe heat removal infrastructure fully operational in GIW-8, -9, -11, -12 and -13.

The pipe within a pipe design, as shown in **Appendix F**, was utilized in the June 2015 expansion pursuant to ease of installation and to further evaluate the effectiveness of this configuration. All of the GIWs utilized as heat removal points continue to extract landfill gas from the head space at the top of the well.

The conversion to the propylene-glycol and closed loop cooling tower showed a significant improvement in operation during periods where ambient temperatures are below the freezing point of water. At the time of this initial report it is too soon to determine potential operational issues associated with expansion completed in June of 2015.

3 DATA SUMMARY

As part of the on-going pilot study, the BL continues significant data collection efforts. The data collection components include in-waste temperature measurements adjacent to extraction points, heat removal at each extraction point and general system operating data.

The collection of in-waste temperature measurements have been recorded near weekly since the installation of the Expanded Heat Extraction Pilot Study System. The (TMPs) profiles are plotted and reviewed weekly. The TMP profiles for the initial reporting period is included in **Appendix A**.

The collection of influent and effluent temperatures at each heat removal point has been recorded near daily since commencement of the pilot study. The flow rate of temperature treated liquid is measured concurrently with temperature measurements at each point. This data is used to calculate the heat removal rate in kilowatts (kW) at the time of the reading. The data point graphs for the initial reporting period are presented in **Appendix B**.

The system data collection is completed to verify proper operation of the heat extraction system. The liquid level in the tank is monitored to verify no loss of heat extraction liquid from the system. The total flow adjacent to the cooling tower is measured to verify adequate flow is available for all heat extraction points. Several temperature measurements are obtained in the cool pipe including the cooling tower discharge to verify proper function of the cooling tower. Since the conversion of the system to propylene-glycol, no significant operation issues have been realized.

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4 SYSTEM MODIFICATIONS

Modifications to the system since the original September 4, 2014 MDNR approval include the Expansion of the Heat Removal System Pilot Study as approved by the MDNR via an April 23, 2015 letter. The expansion included the installation of five (5) additional heat extraction points in GIW-8, -9, -11, -12 and -13. A separate influent and effluent line were installed to segregate the flow between the north and south heat extraction rows. The installation was initiated and completed on June 26, 2015. As-built drawings of the system can be found in **Appendix F**. During the construction of the expansion, the majority of the influent lines were insulated from the cooling tower to the heat removal points. The insulation was installed to reduce the effect of ambient temperatures during warmer months.

5 ANALYSIS AND FINDINGS

A comparison of two heat removal point designs was completed pursuant to data collected. The two designs utilized included a pipe within pipe and a continuous loop design constructed of stainless steel tubing.

The first heat extraction point design includes a pipe within a pipe. Specifically, a small diameter pipe is installed within a larger diameter pipe. The small diameter is open approximately two foot from the end of the sealed larger diameter pipe. The cool influent liquid is directed down the point, inside the smaller diameter pipe, to the base of the larger diameter pipe. The liquid is then pushed up the annulus between the pipes and discharged through the return line to the equalization tank. This design is presented graphically in **Appendix F**. This design demonstrated the ability to lower temperatures within the well casing with very little retardation. The graph below demonstrates the relatively short time period required to cool the liquid in the GIW casing relatively close to the inflow liquid temperature.

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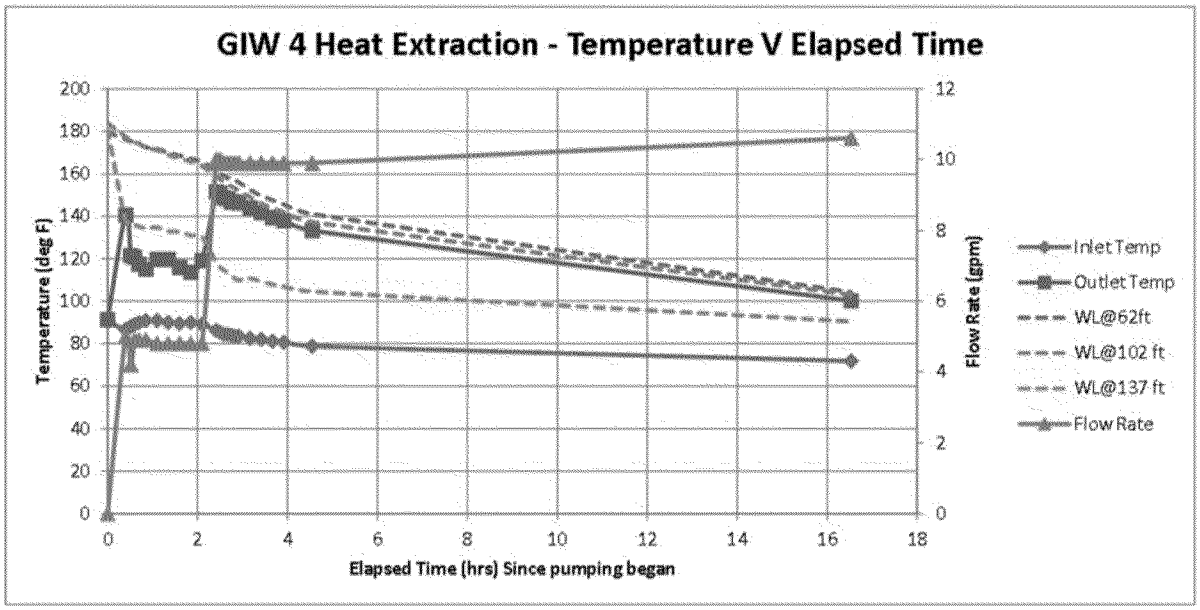
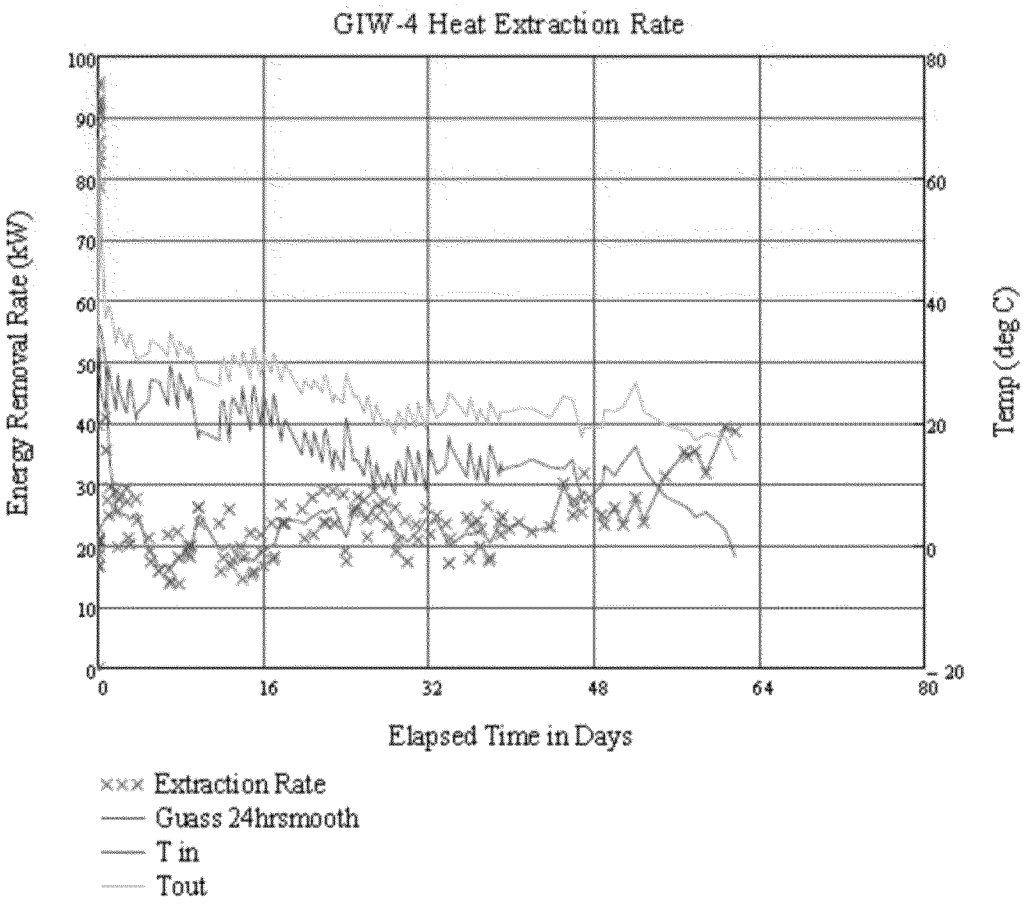


The pipe in pipe design has shown the ability to remove energy at a rate of above 20 kW for an extended period of time when constructed to a length of one-hundred (100) feet or greater. This is shown in the graphic below.

WLLFOIA4312 - 001 - 0017918



The second heat extraction point design was constructed of a continuous loop pipe system. The cool liquid was forced down the tubing to the bottom of the point to a U-tube connection. Then the liquid was forced up the loop and discharged into the return line piping and finally the equalization tank. This design is currently installed in GIW-2, -3, -4, -5, -6, -7 and -10. As shown in the **Appendix B**, this system was able to maintain a removal rate of 8 to 10 kW at locations with a depth of one-hundred (100) feet or greater.

The comparison of data collected from both heat removal methods exhibited energy removal rates near or above 10 kW for installations of one-hundred feet or greater. Several additional variables impact the heat extraction rate at a given point. These include, but are not limited to: depth of point, inlet temperature, temperature boundary conditions in near proximity to the point, and heat gradient at the extraction point. The recently installed heat extraction points in GIW-8, - 9, -11, -12 and -13 are still trending towards a steady state energy extraction rate (kW). Additional time and data collection is needed to realize the steady state extraction rate at these points under the current conditions.

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The TMP Temperature Profile Graphs (**Appendix A**) show a significant decrease in temperature at the five (5) foot offset to the north of GIW-5 and -10 (TMP 5-5N and TMP 10-5N). These temperature profiles show the heat extraction point is able to maintain a temperature below 160 ^{o} F to the depth of the extraction point installation at this relative offset. [Note that the offset distance may be slightly skewed due to differential settlement of the GIW prior to the installation of the TMPs adjacent.] The TMPs at the nine (9) foot offset (TMP 5-9N and TMP 10-9N) also showed a significant reduction in temperature relative to the temperatures measured prior to heat extraction.

The TMP temperature profiles five (5) and nine (9) feet south of the heat extraction points showed moderate decreases in temperature. The difference in temperature reduction in comparison of the TMPs on the north and the south shows that the heat gradient is being conducted from the south. This supports the premise that the heat gradient, above historically normal landfill temperatures, is from the south only; this heat may be a remnant of heat generated in the vicinity when active reaction and settlement were occurring primarily prior to 2014. The TMPs at larger offset distances have shown to be affected by the heat removal also.

The data plots for the heat extraction points display a significant relationship between energy removed (kW) and the depth of the heat extraction point element (**Appendix B**). The deeper installations showed a greater value of heat extraction. The heat extraction elements showed an initial removal nearly twice the steady-state removal rate. It appears to take several weeks for a heat extraction point, consistently operated, to reach a steady-state of heat removal.

The wet bulb temperature at BL can vary from near 30^{o} F to approximately 80^{o} F. The current closed loop system is designed for the liquid to discharge near the wet bulb temperature at a low temperature not to exceed 40^{o} F.

At the time of this submittal, the additional heat extraction points (GIW-8, -9, -11, -12 and -13) have only been operated for a period of approximately five weeks. These heat extraction points are still trending to a steady state of energy removal.

6 SUMMARY

Between the dates October 24, 2014 to July 15, 2015, the Expanded Heat Removal Pilot Study has resulted in the extraction of approximately 1.2 x 10^{12} joules of heat energy. Local temperature reduction has been observed in waste material near the heat removal points. Recent installation of deeper additional heat removal points is providing important new data. Continued monitoring of the newly-expanded system will allow evaluation of the impact that the heat extraction may be having on the presence or movement of heat in the vicinity. In addition, continuation of the pilot study will provide data needed to support the design of an engineered

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thermal barrier or supplementation of the existing heat removal points if necessary. Bridgeton Landfill herein requests that MDNR approve continuation of the pilot heat removal study.

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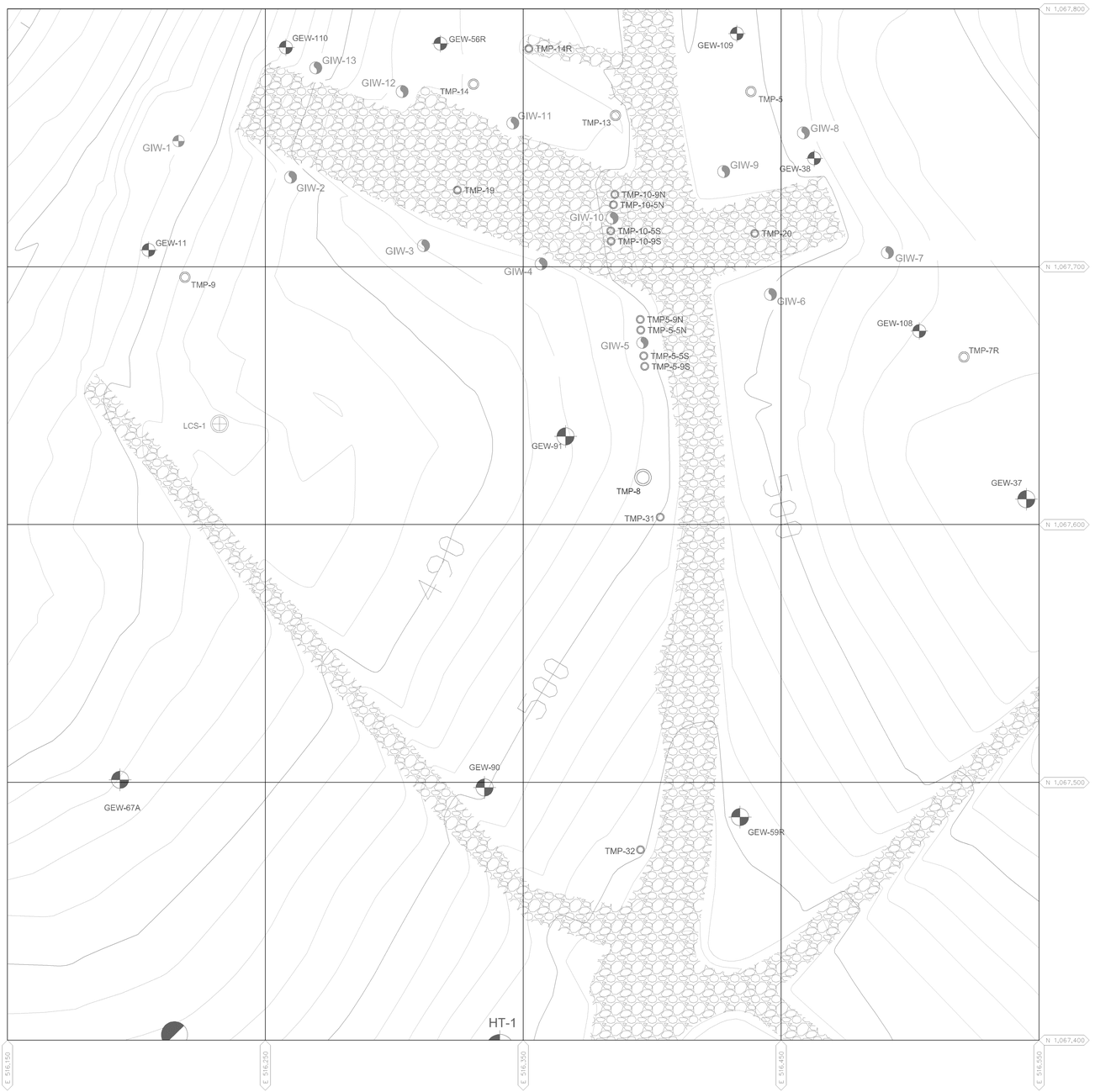
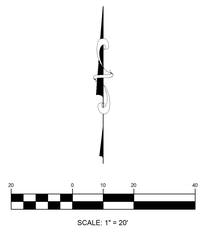
APPENDIX A – TEMPERATURE MONITOR PROBE GRAPHS AND LAYOUT MAP





LEGEND

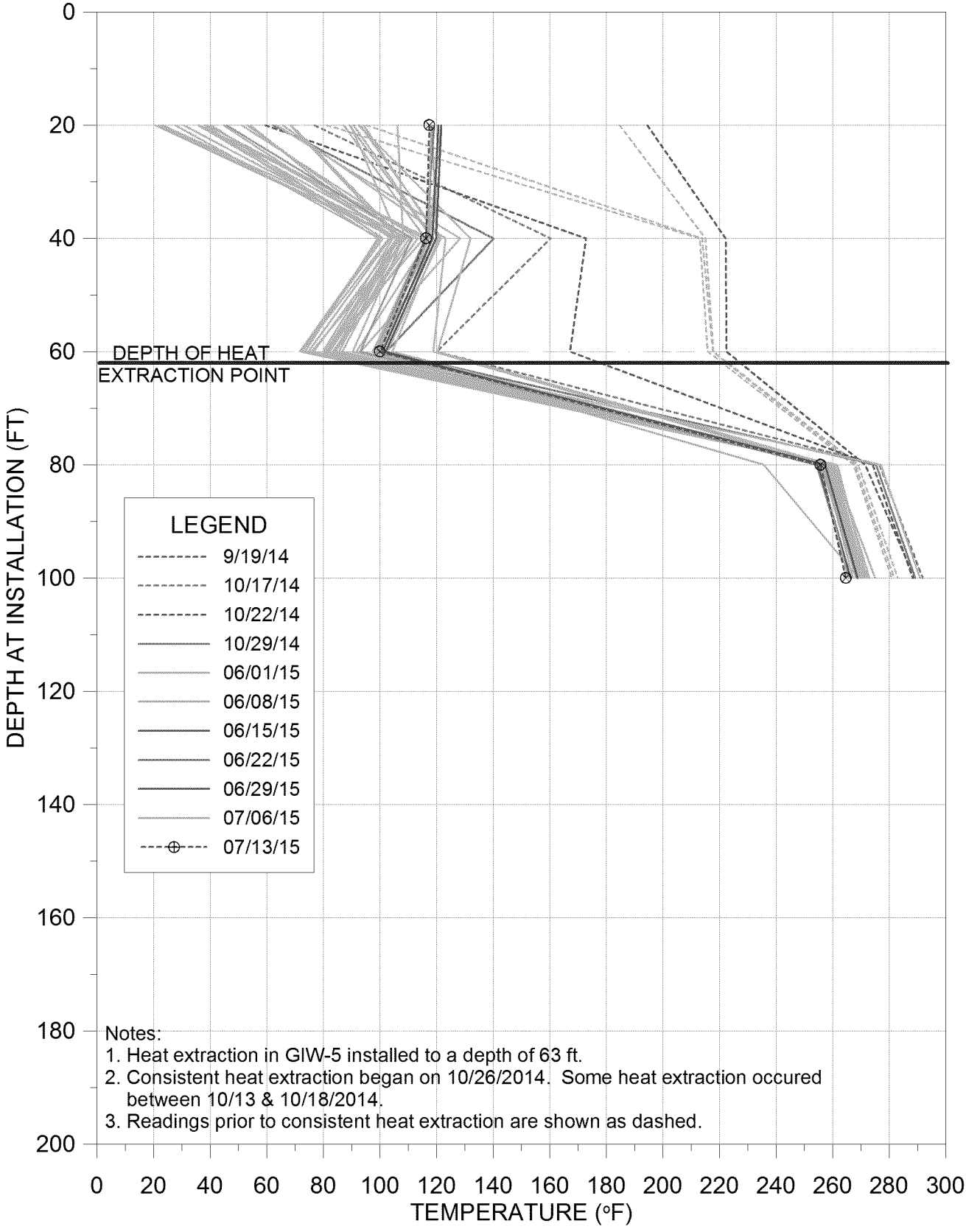
- EXISTING GRADE (2' CONTOUR)
- 500 EXISTING GRADE (10' CONTOUR)
- EXISTING GAS EXTRACTION WELL
- EXISTING GAS INTERCEPTOR WELL
- EXISTING TEMPERATURE MONITORING PROBE
- AS-BUILT HEAT EXTRACTION AT GAS INTERCEPTOR WELL
- AS-BUILT TEMPERATURE MONITORING PROBE

TMP INSTALLATION			
ID	Northing	Easting	Depth (ft)
TMP-19	1067729.43	516324.34	140
TMP-14R	1067784.62	516352.17	140
TMP-20	1067712.59	516439.87	140
TMP-5-9S	1067661.16	516397.18	100
TMP-5-5S	1067665.2	516396.79	100
TMP-5-5N	1067675.28	516395.69	100
TMP-5-9N	1067679.41	516395.37	100
TMP-10-9S	1067709.77	516384.13	100
TMP-10-5S	1067713.85	516384	100
TMP-10-5N	1067723.9	516384.95	100
TMP-10-9N	1067727.77	516385.53	100
TMP-31	1067602.84	516403.11	192.96
TMP-32	1067474.00	516395.36	205.2

NOTES:
1.) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	2014 TEMPERATURE MONITORING PROBE INSTALLATION AS-BUILT DRAWINGS		JANUARY 2015 DESIGNED BY: AMR APPROVED BY: ALK
TMP INSTALLATION PLAN VIEW		Engineering for a Better World FEEZOR ENGINEERING, INC.	DRAWING NO.: **001**
PROJECT NUMBER: BT-045 | FILE PATH:			REVISION | DATE

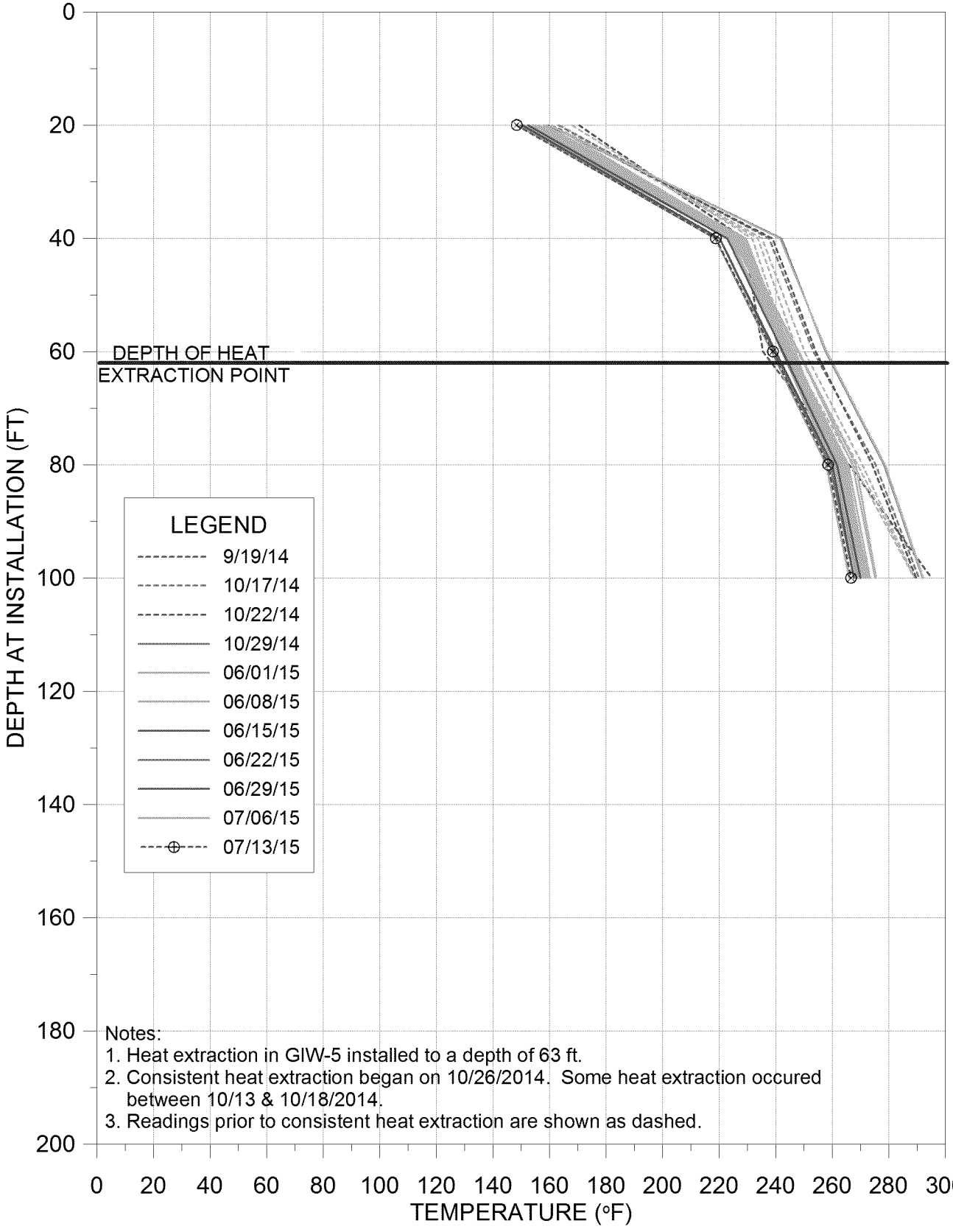
TMP-5-5N



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0017924

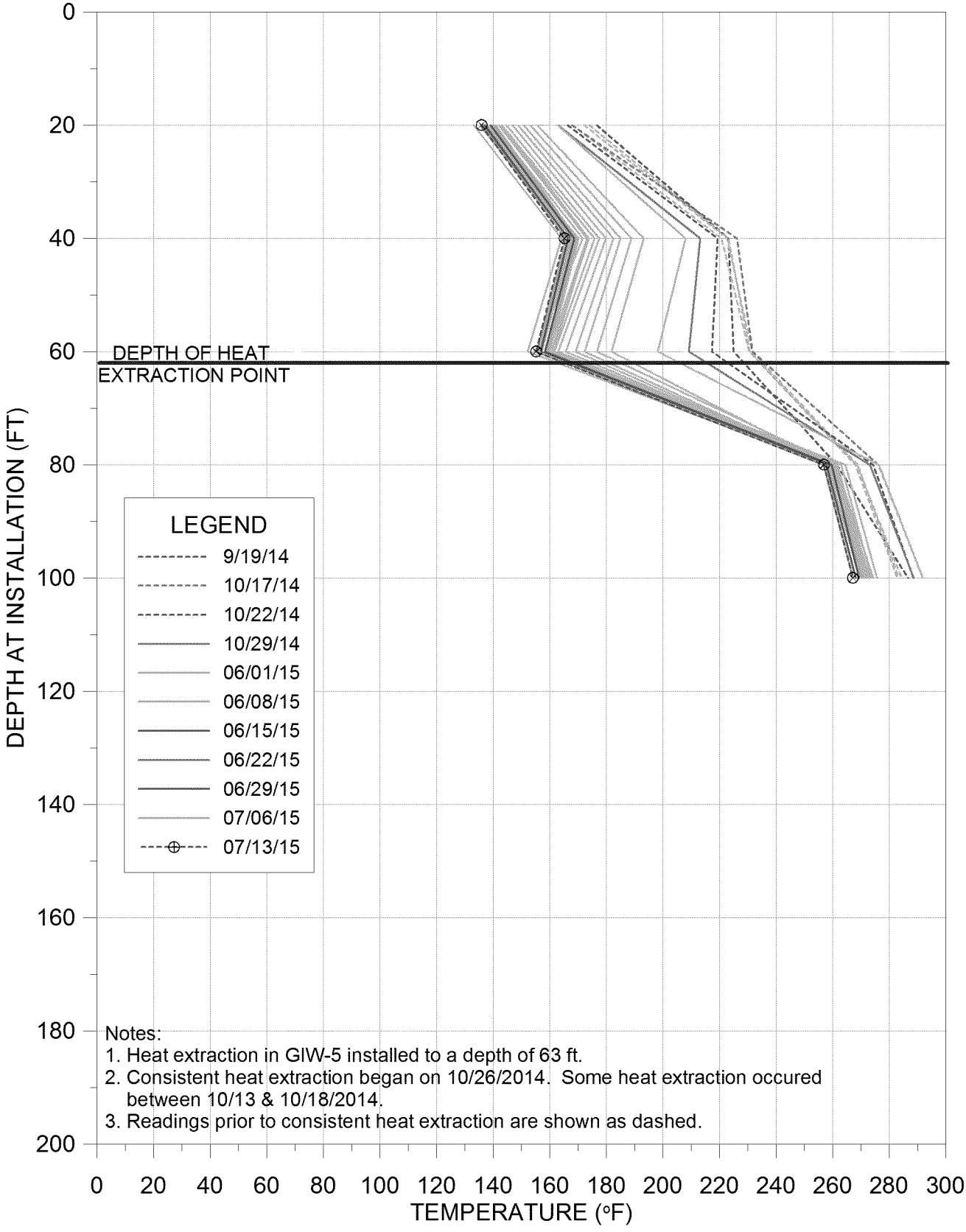
TMP-5-5S



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0017925

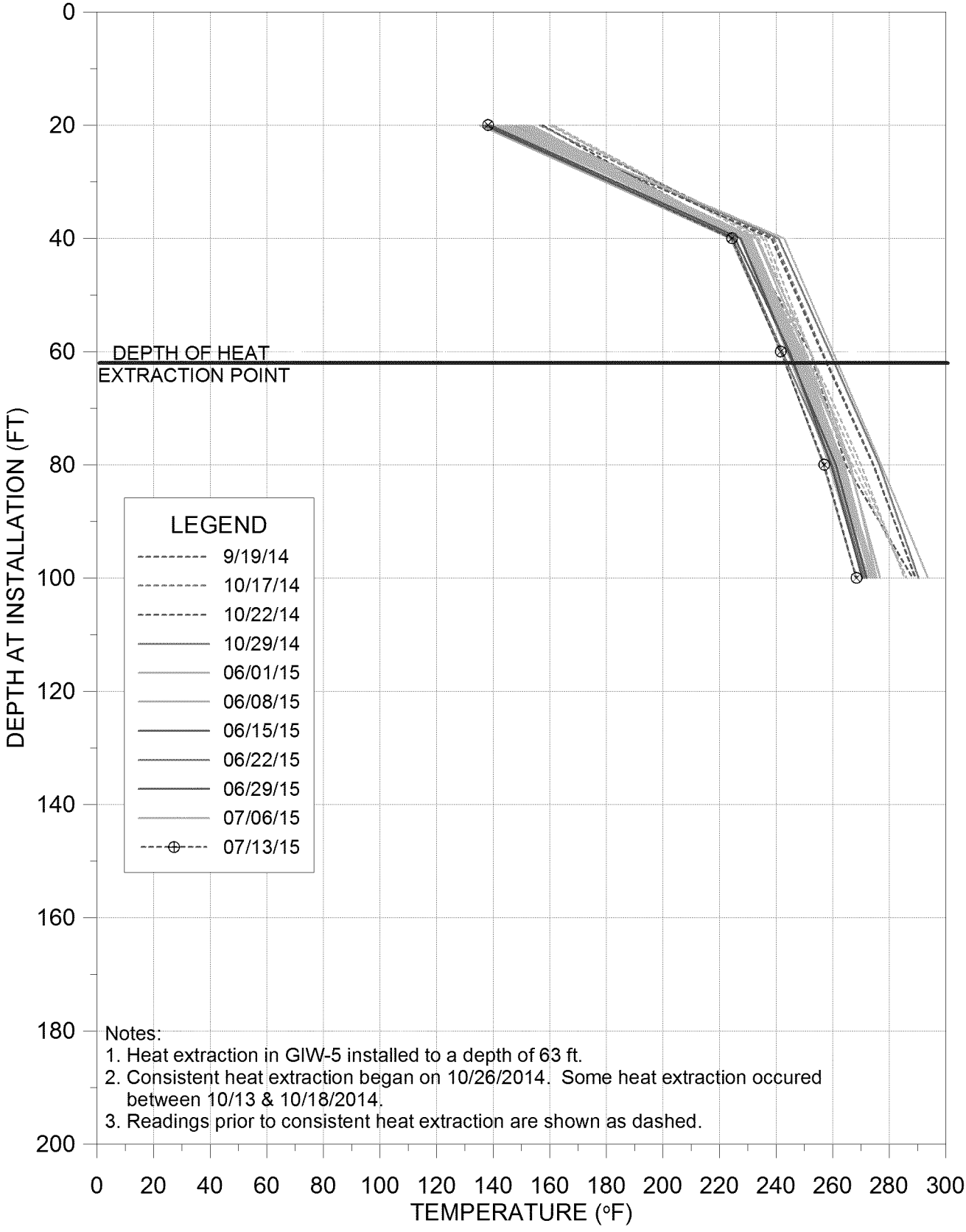
TMP-5-9N



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0017926

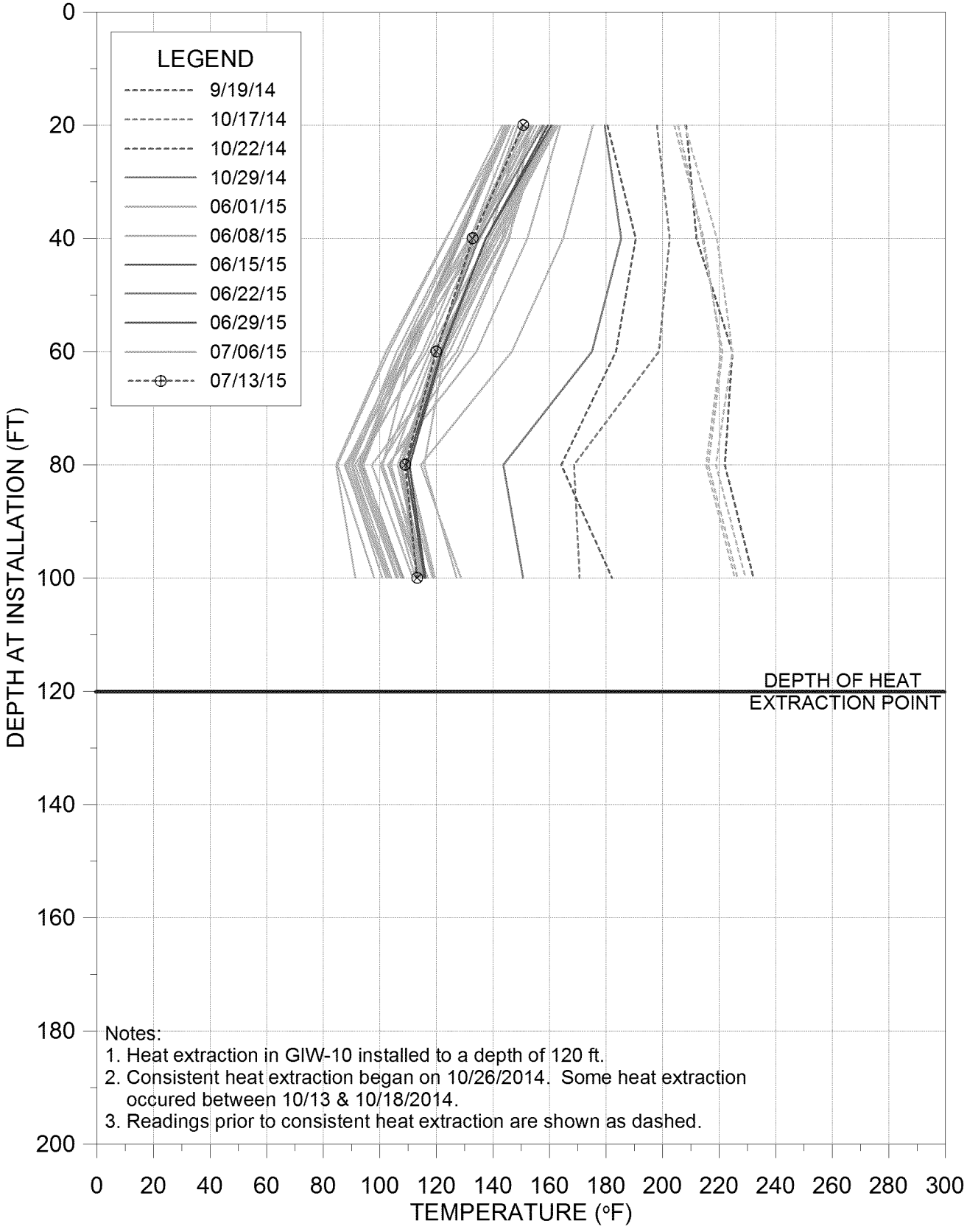
TMP-5-9S



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0017927

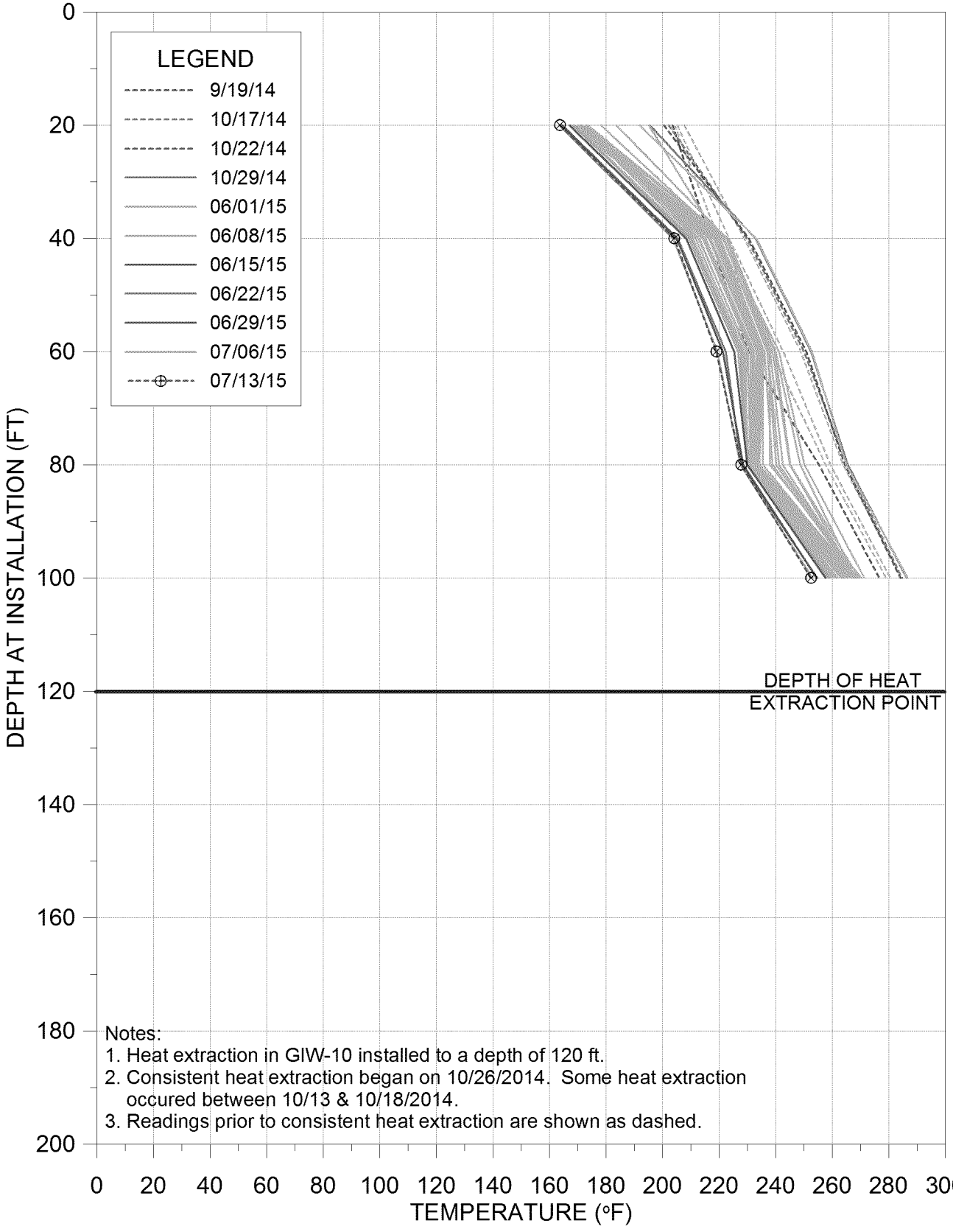
TMP-10-5N



Notes:
1. Heat extraction in GIW-10 installed to a depth of 120 ft.
2. Consistent heat extraction began on 10/26/2014. Some heat extraction occured between 10/13 & 10/18/2014.
3. Readings prior to consistent heat extraction are shown as dashed.

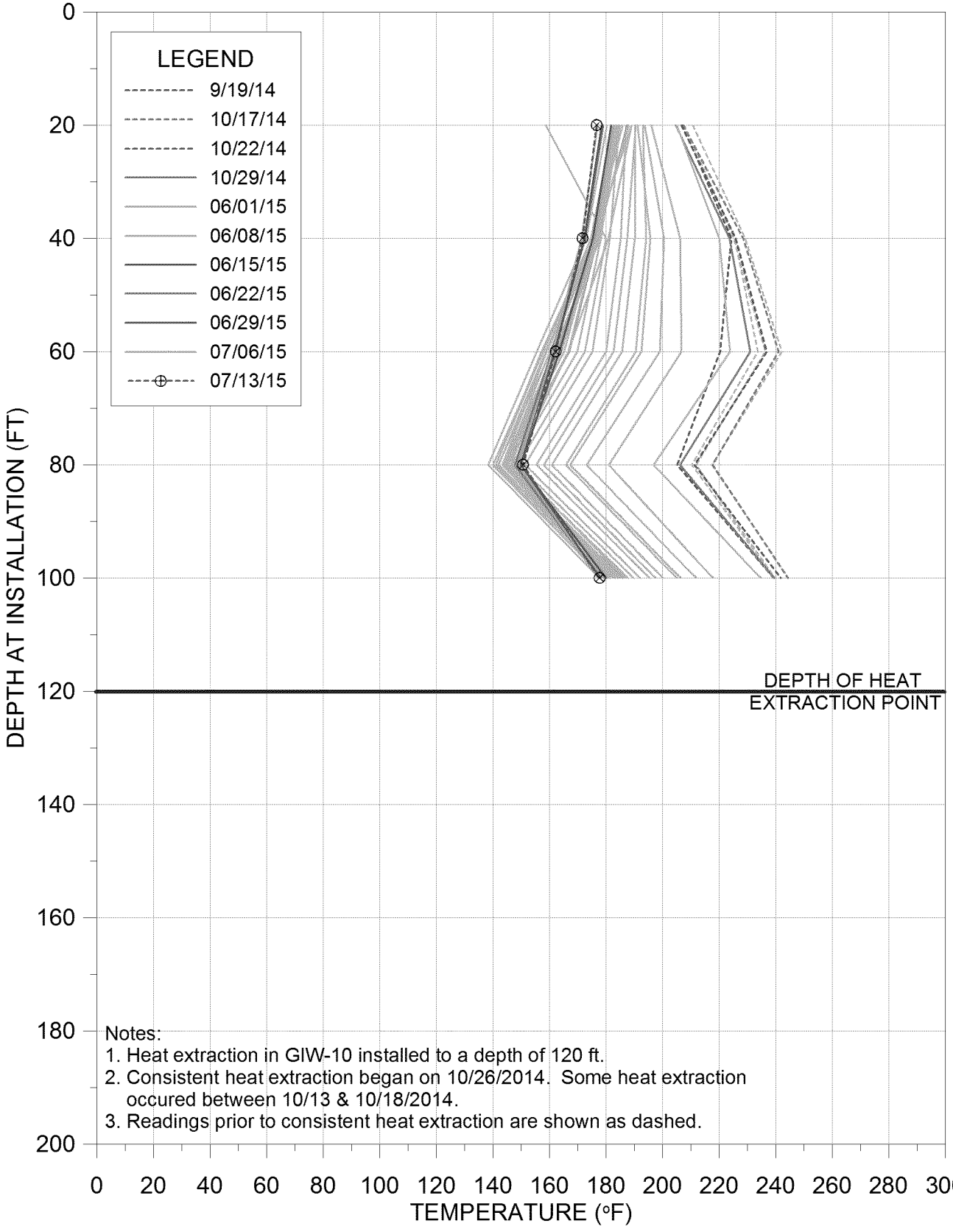
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-10-5S



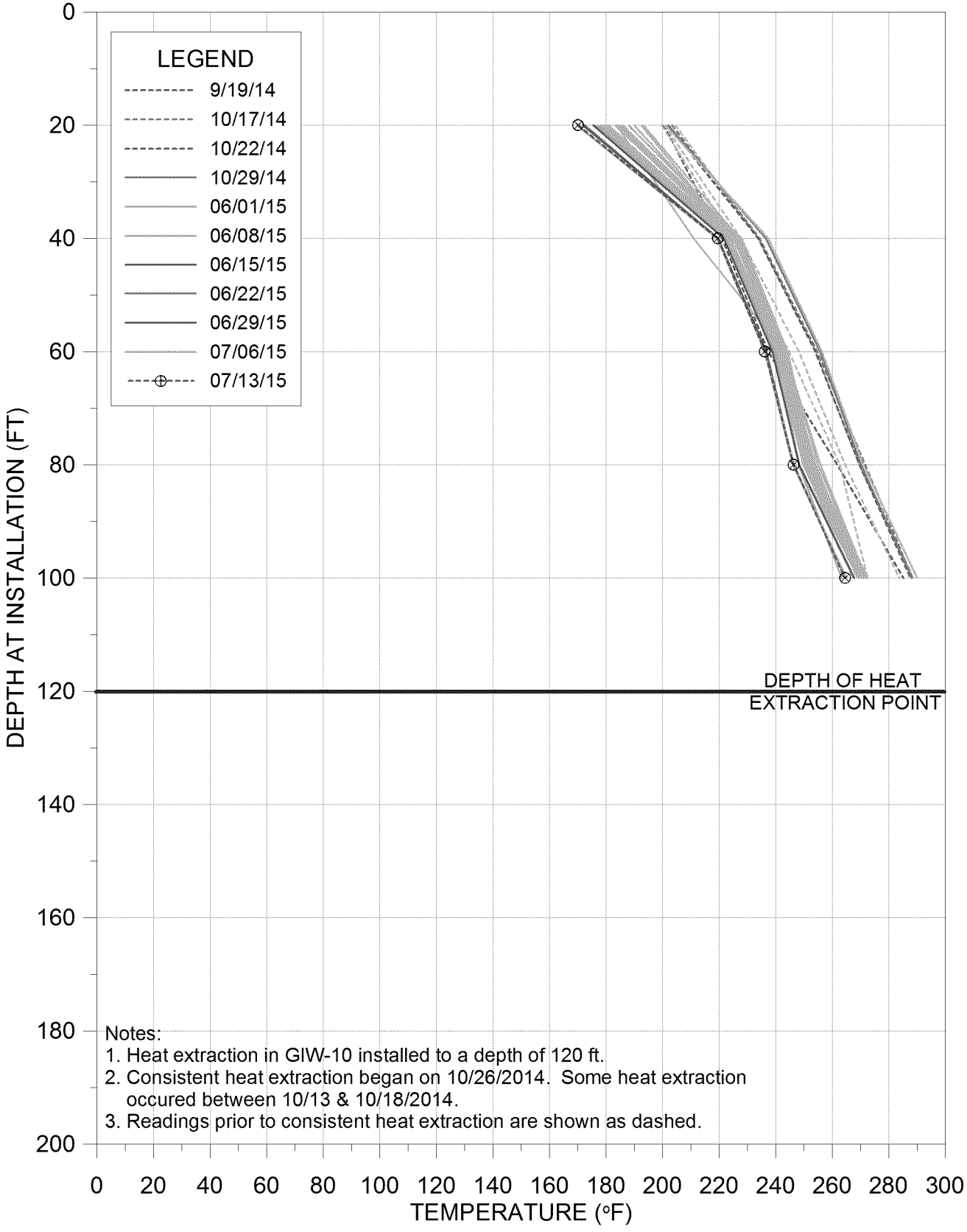
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-10-9N



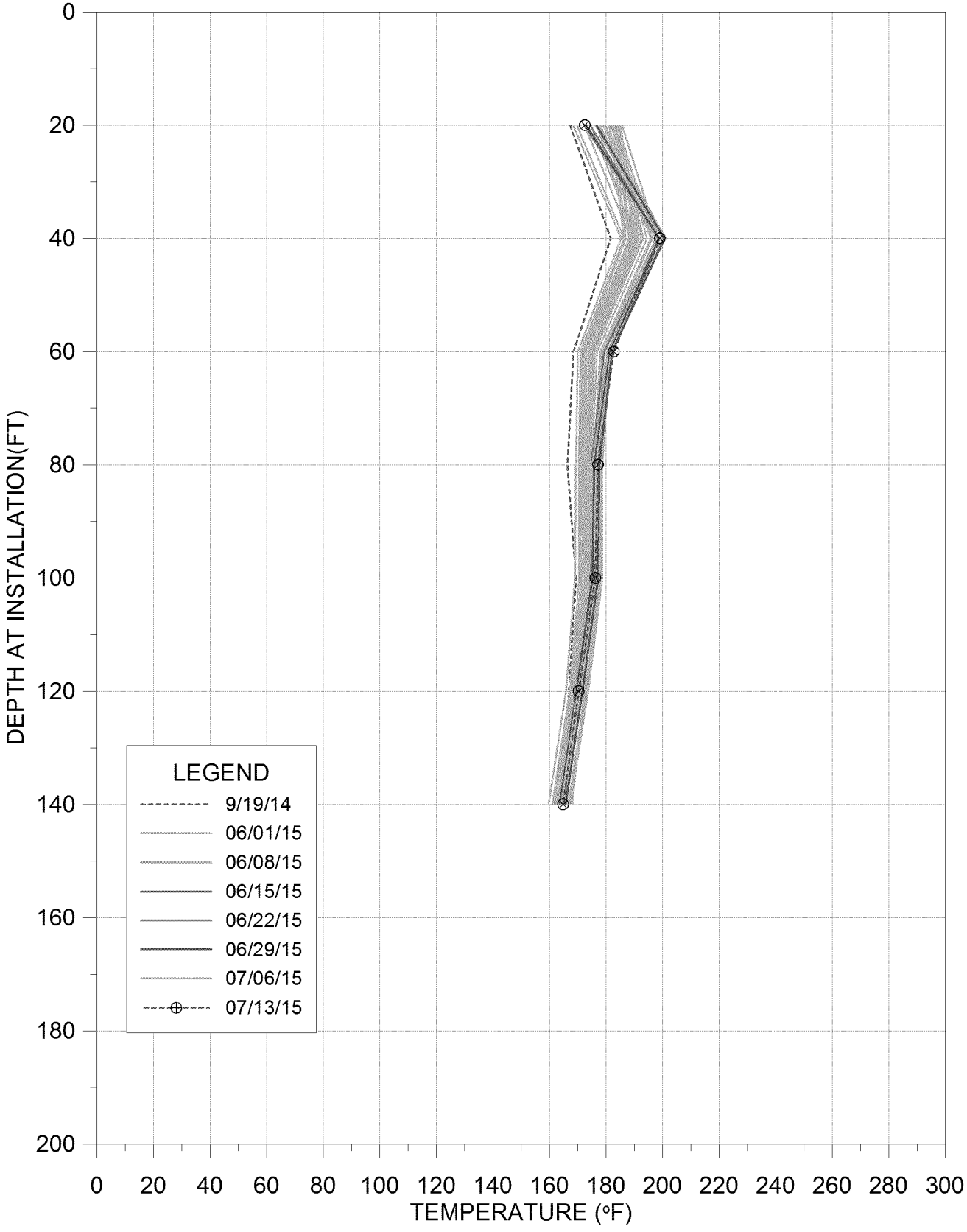
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-10-9S



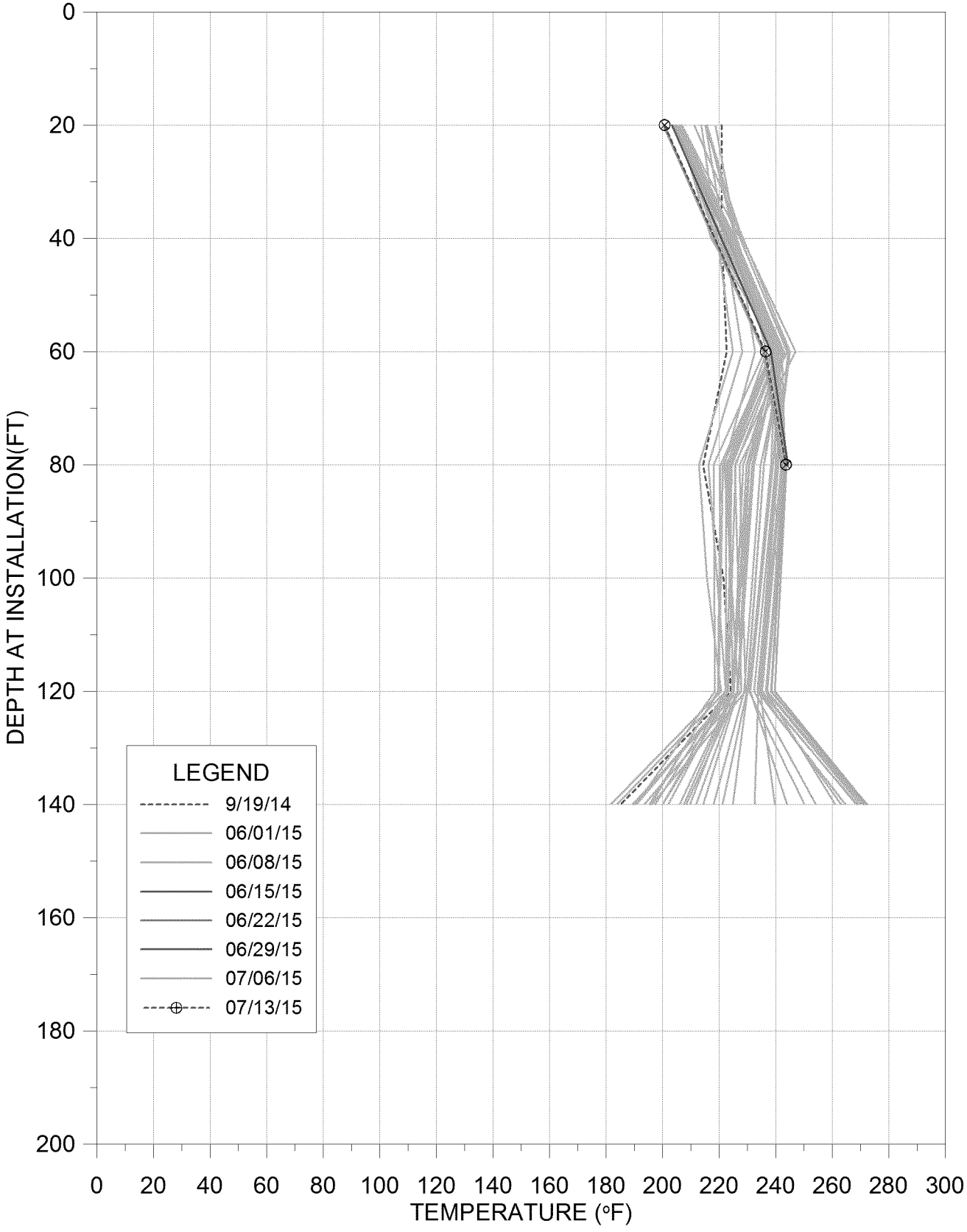
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-14R



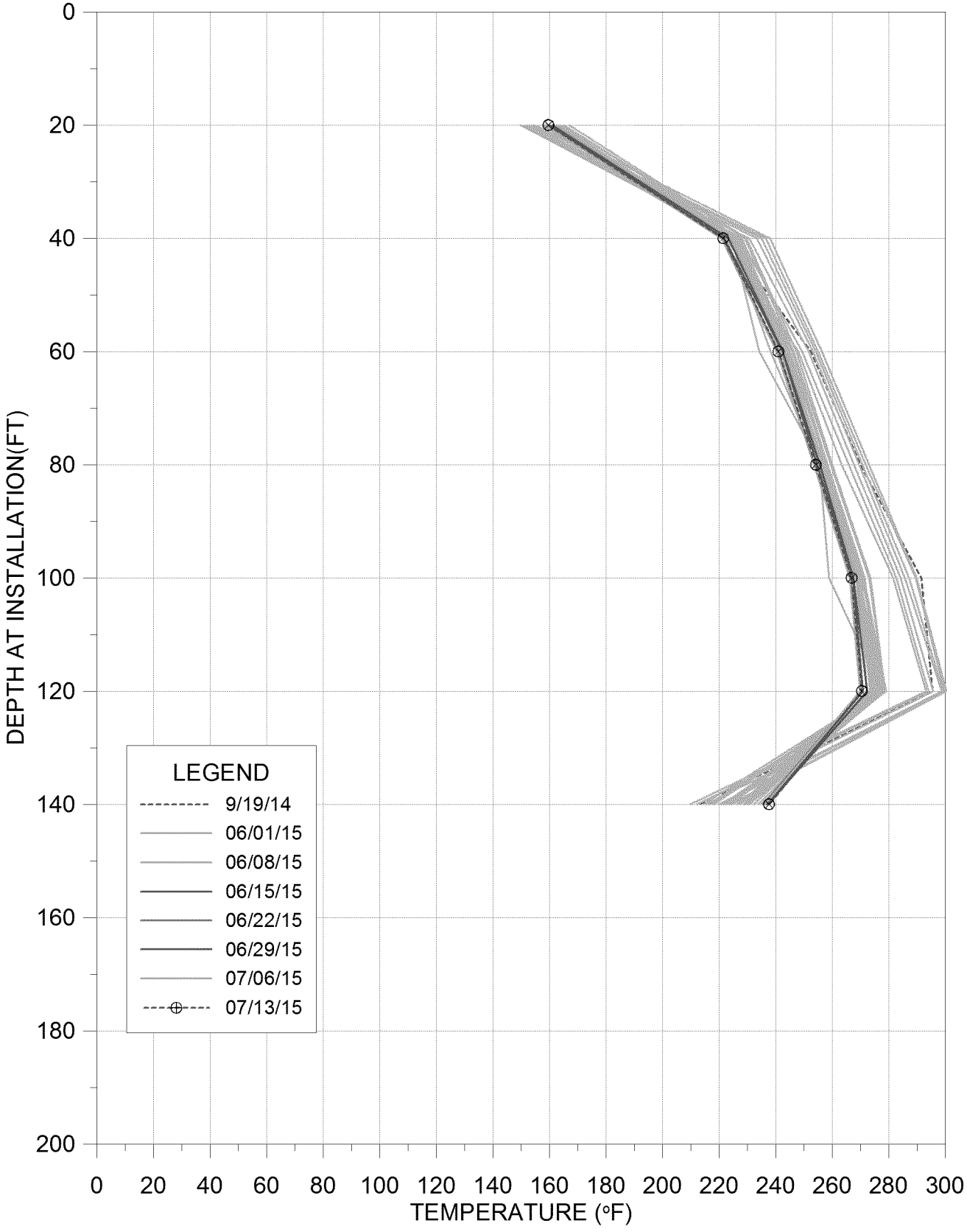
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-19



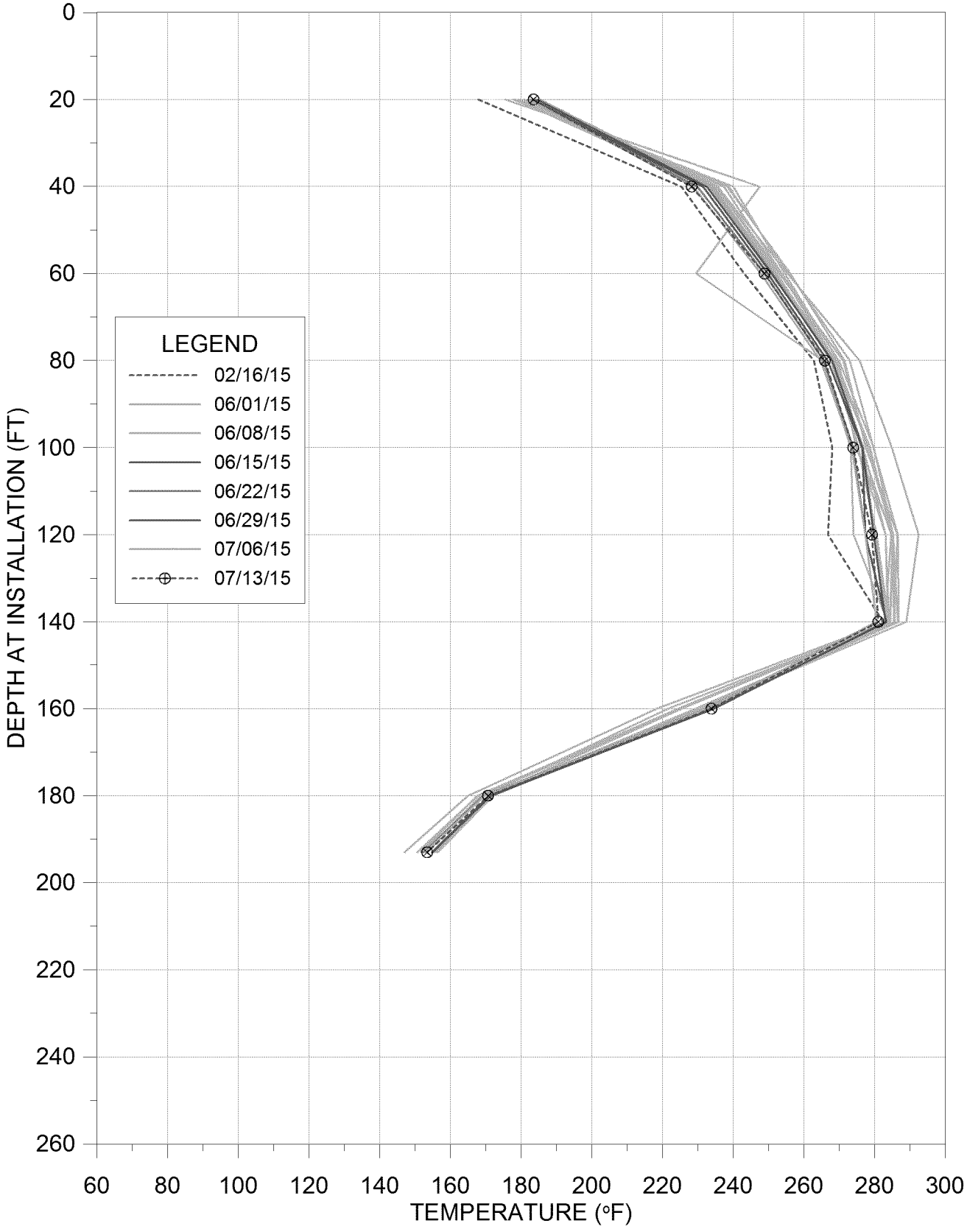
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-20



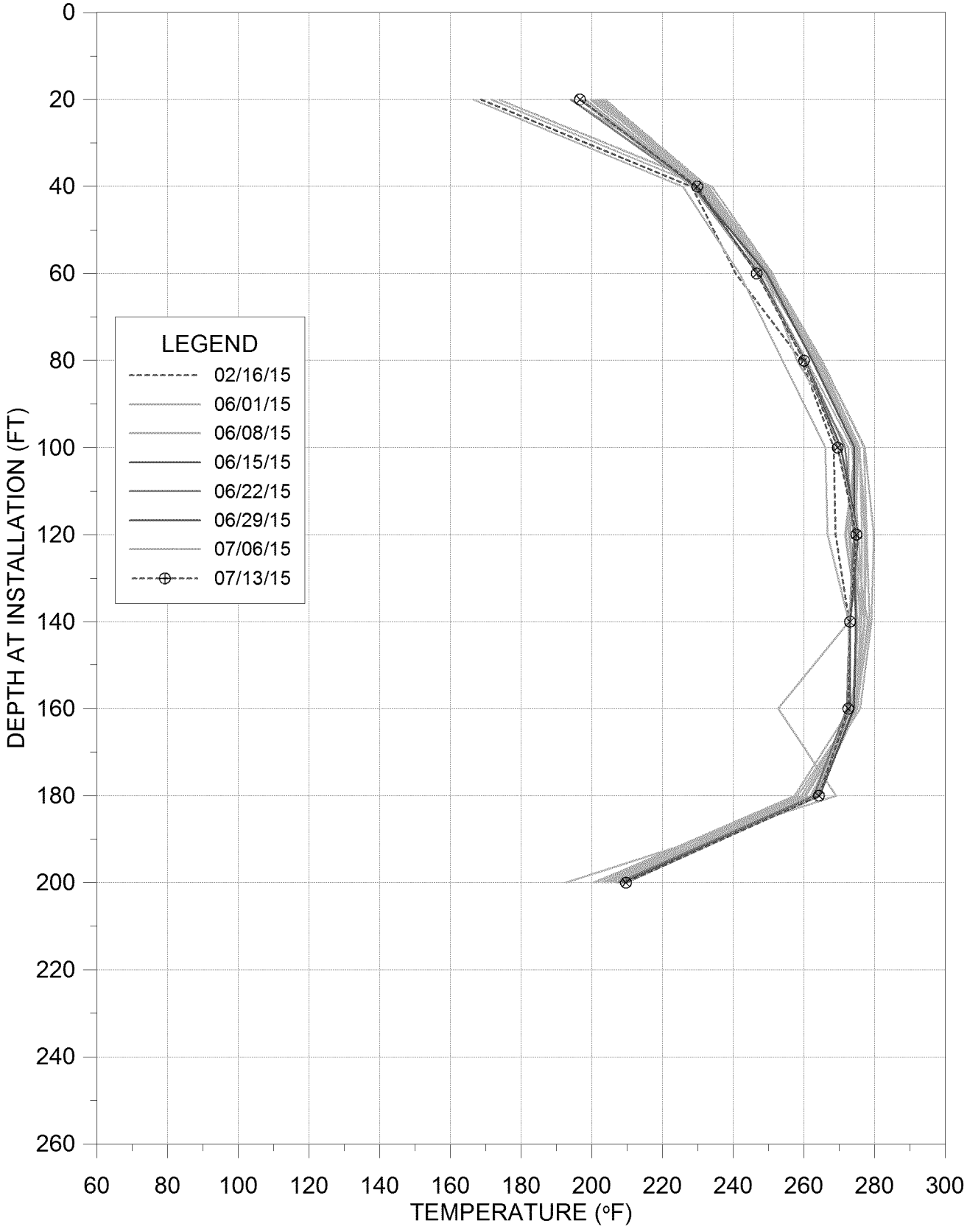
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-31



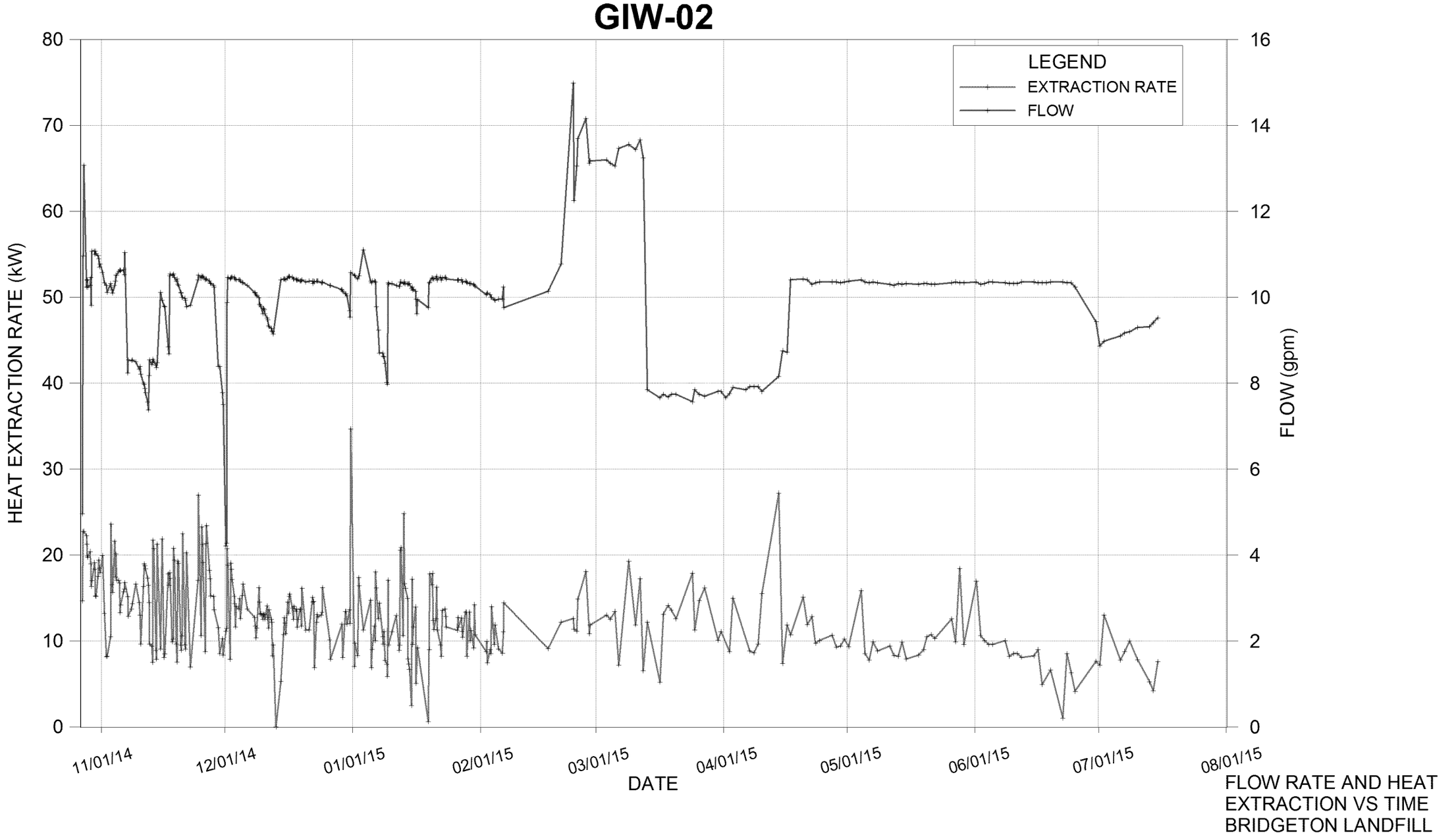
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

TMP-32



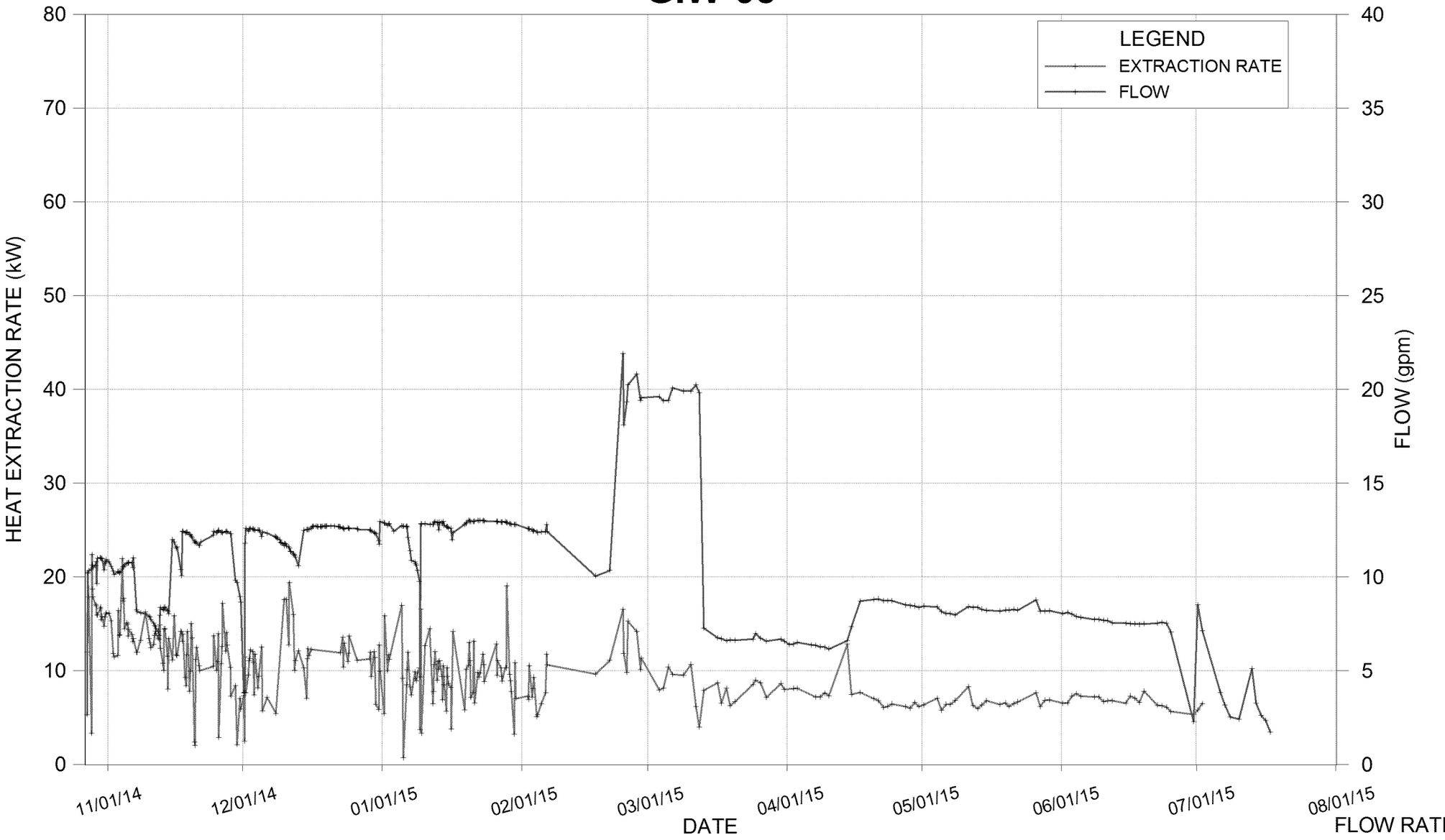
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL

APPENDIX B – HEAT REMOVAL POINT DATA

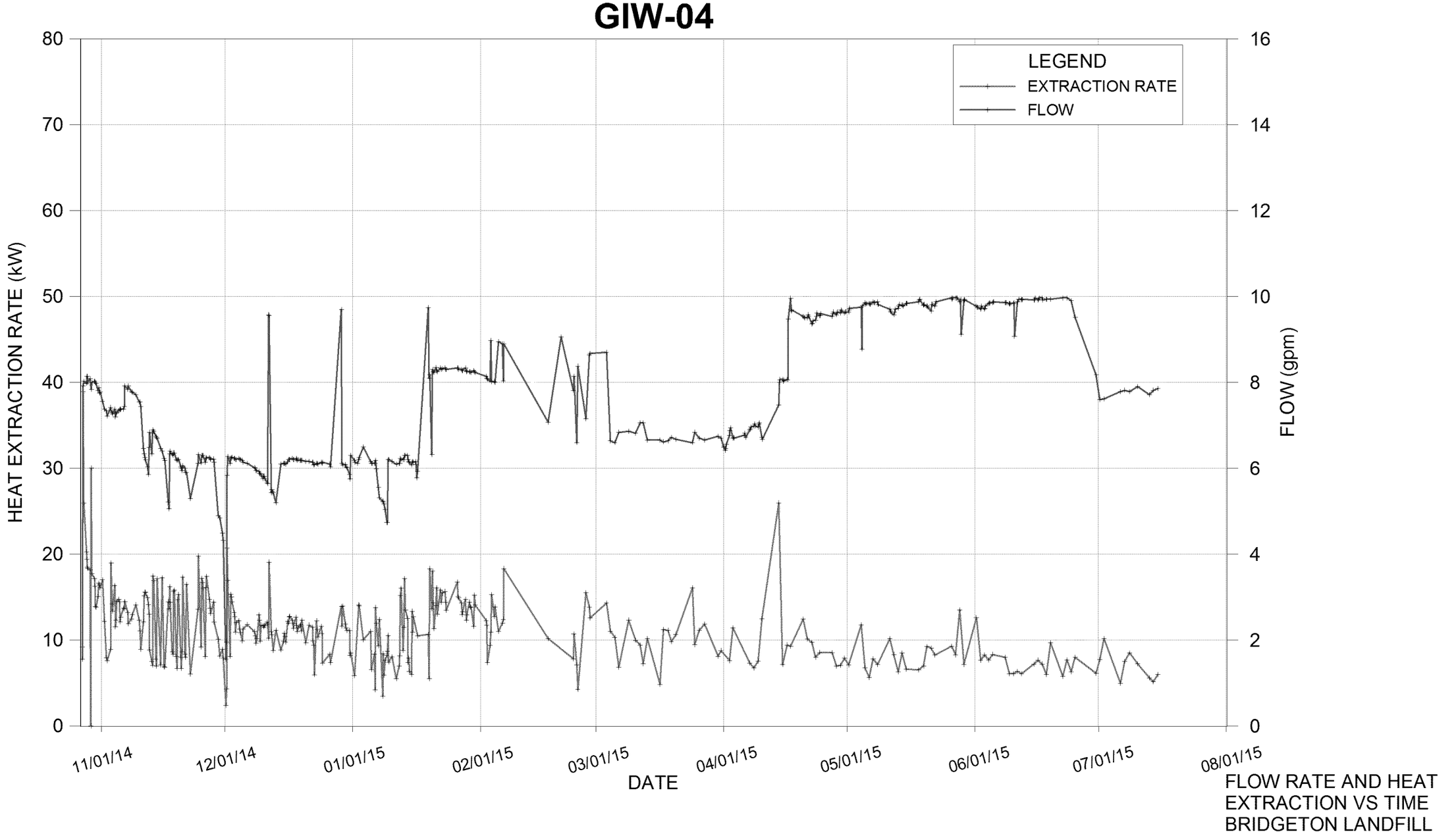


FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

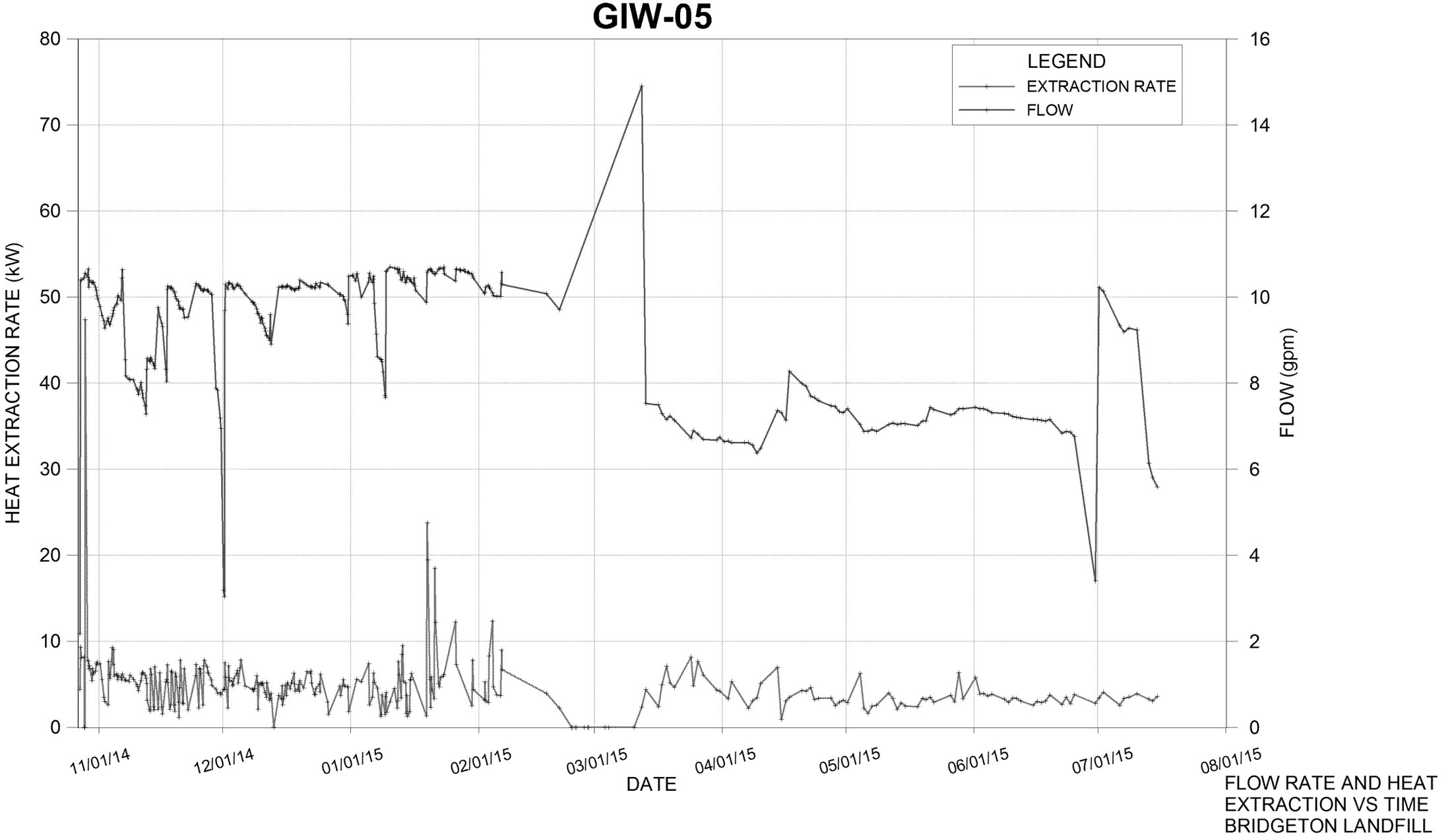
GIW-03



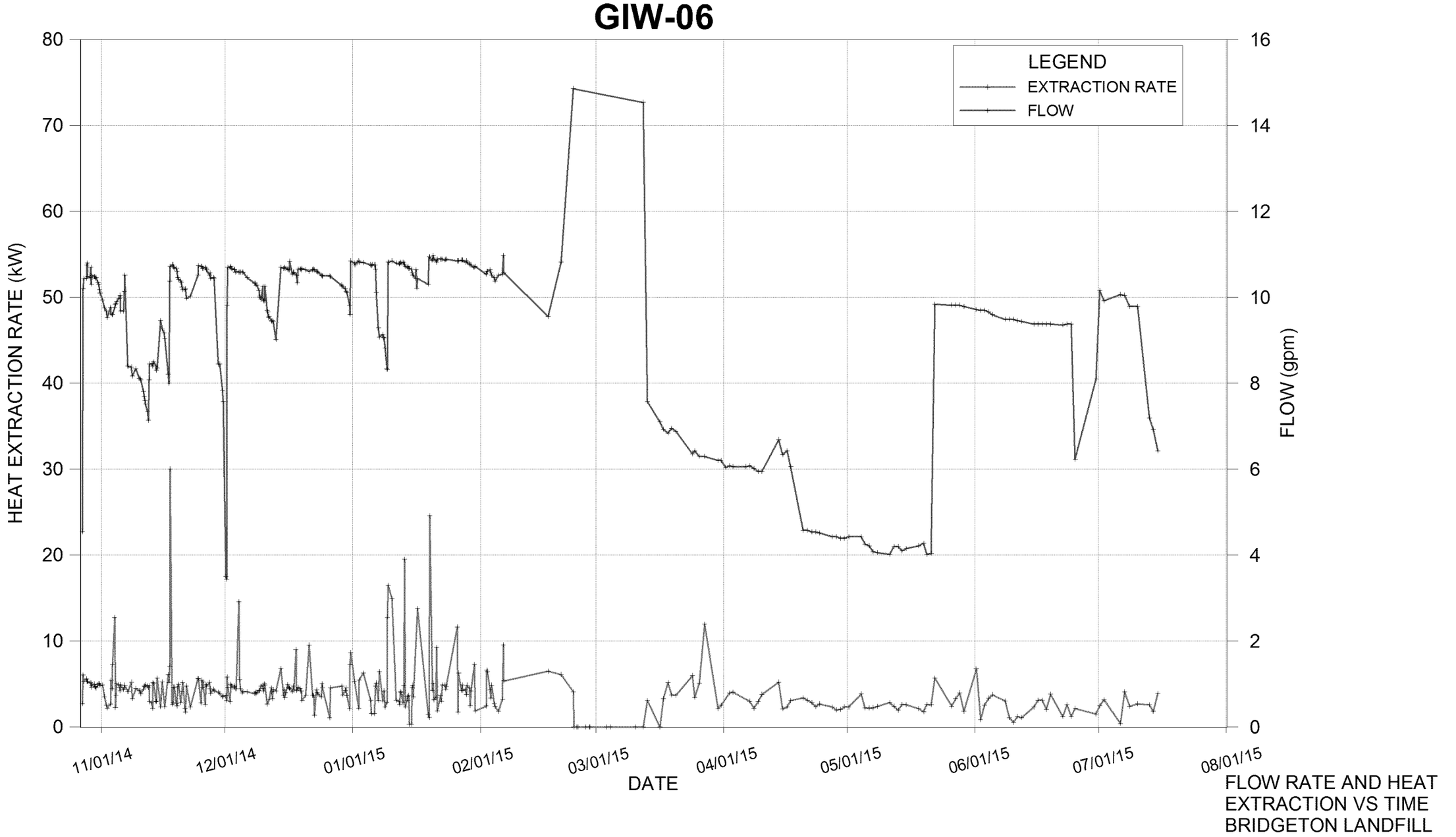
FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL



FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

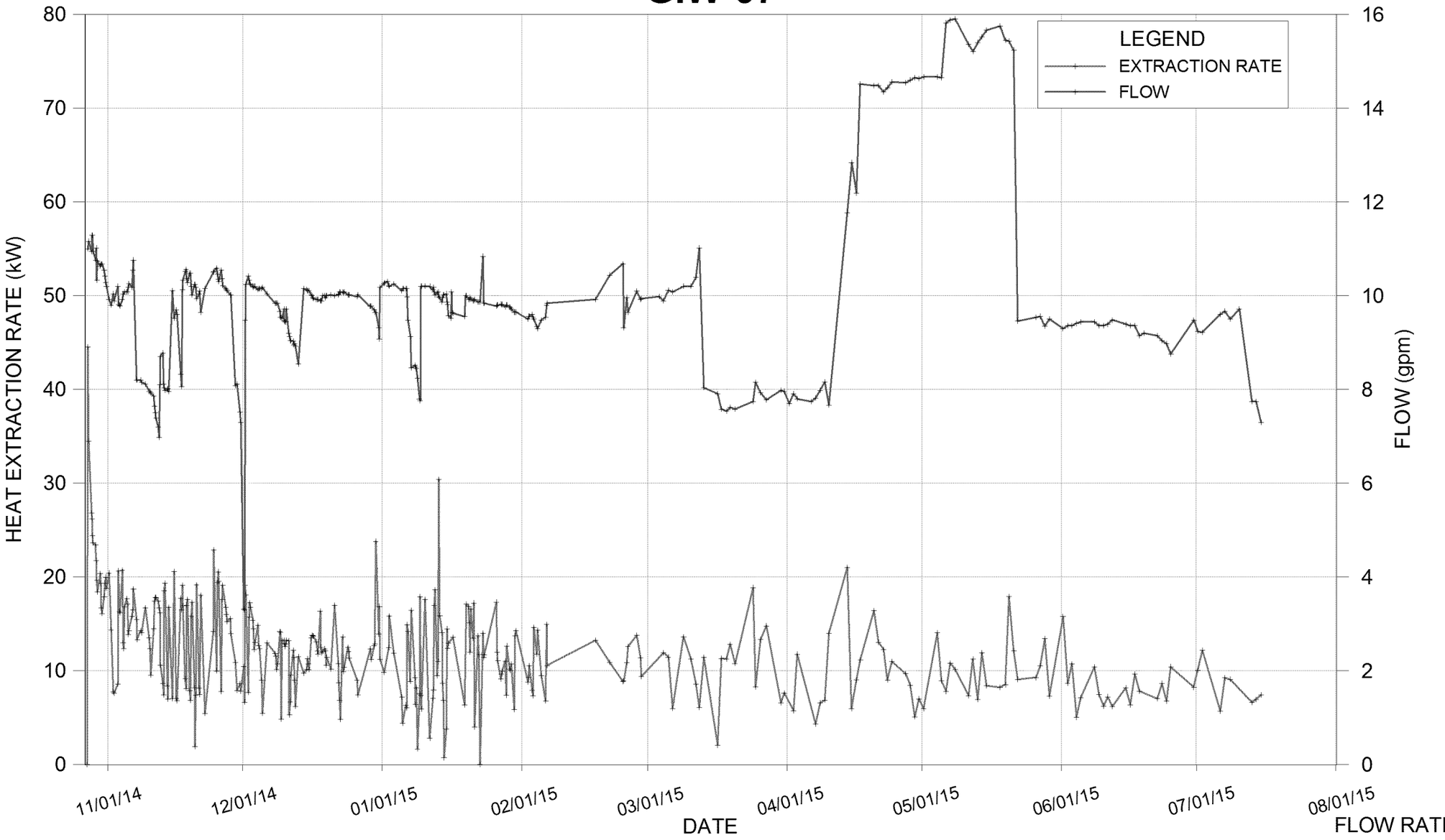


FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

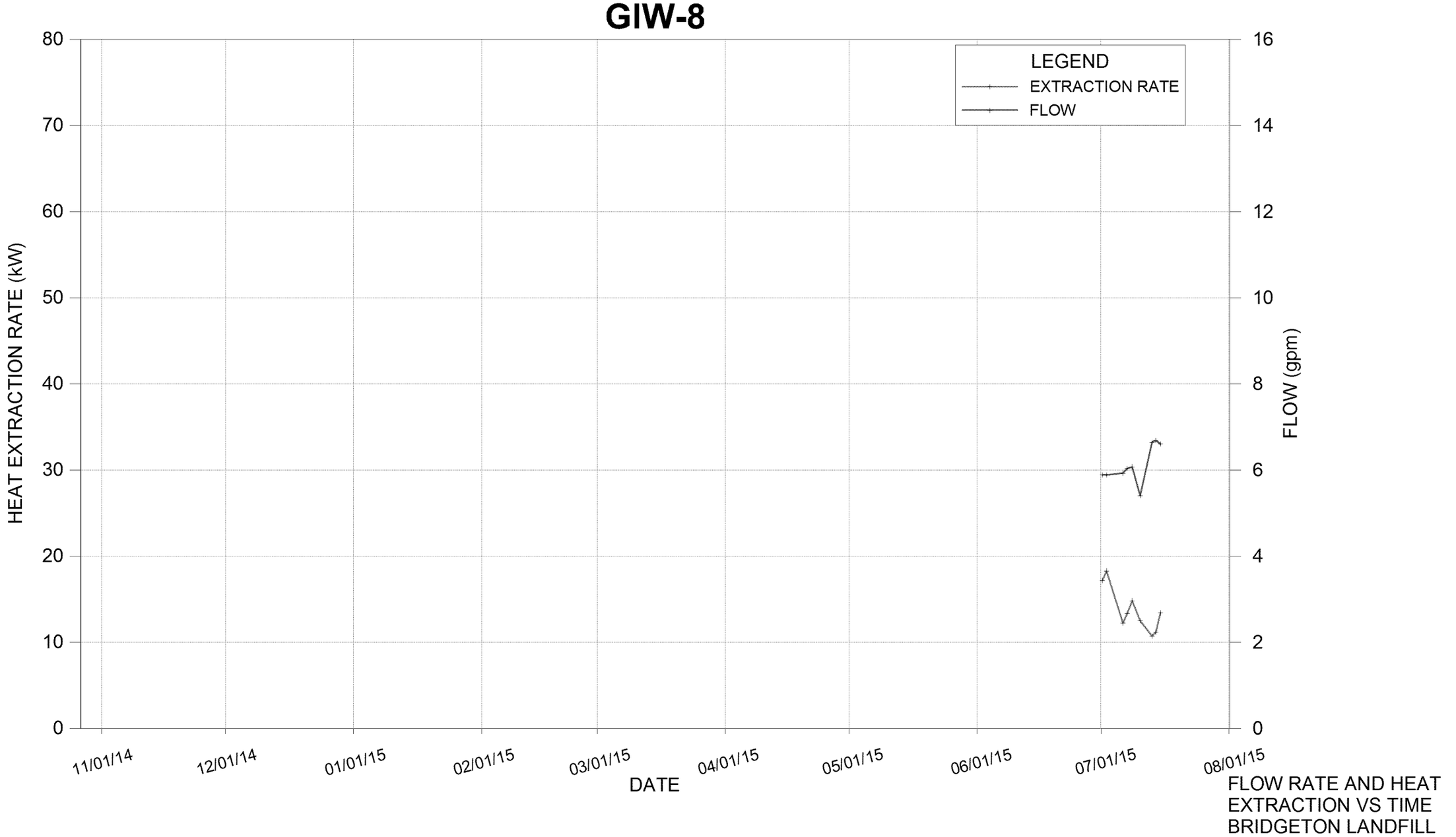


FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

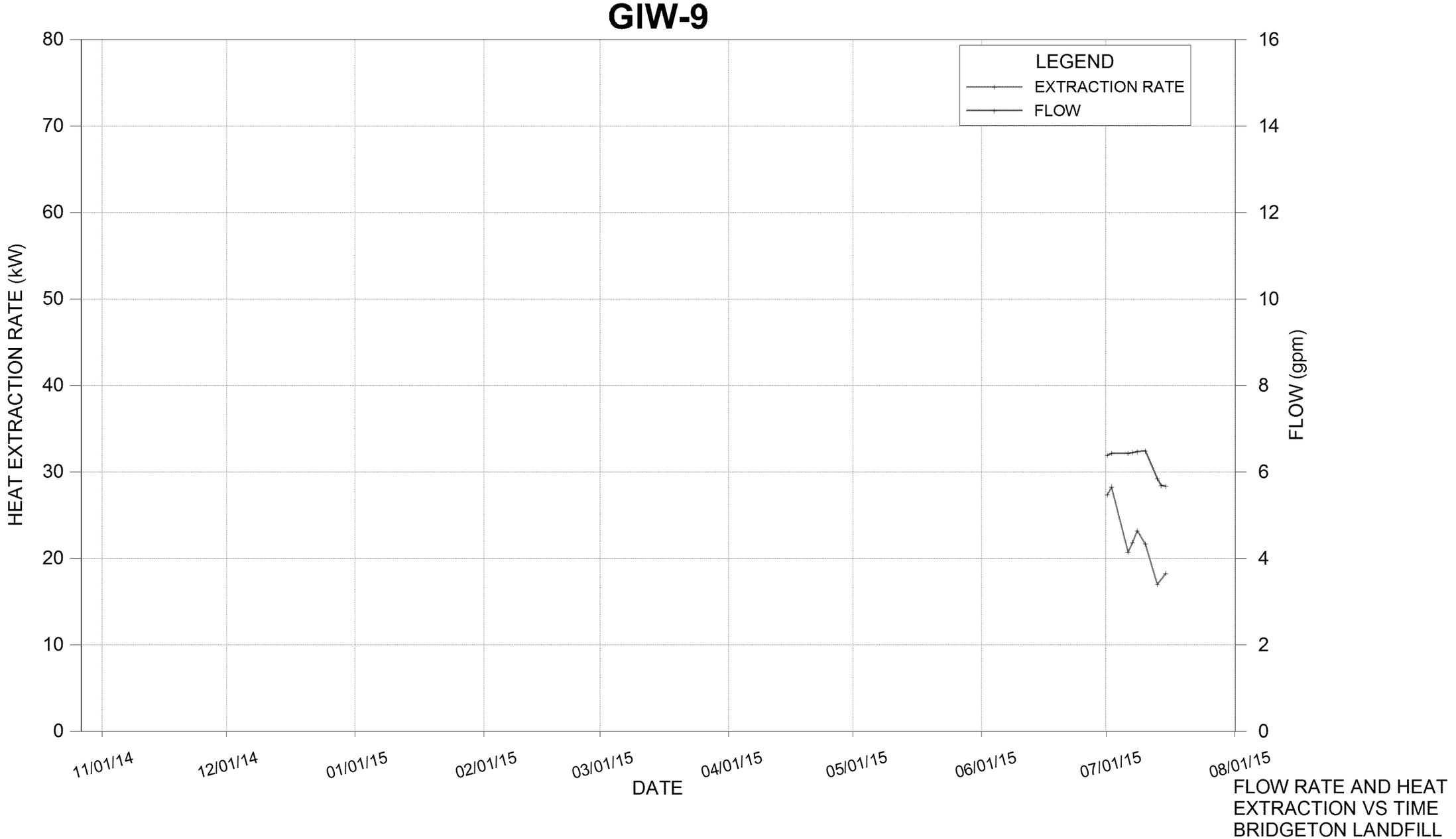
GIW-07



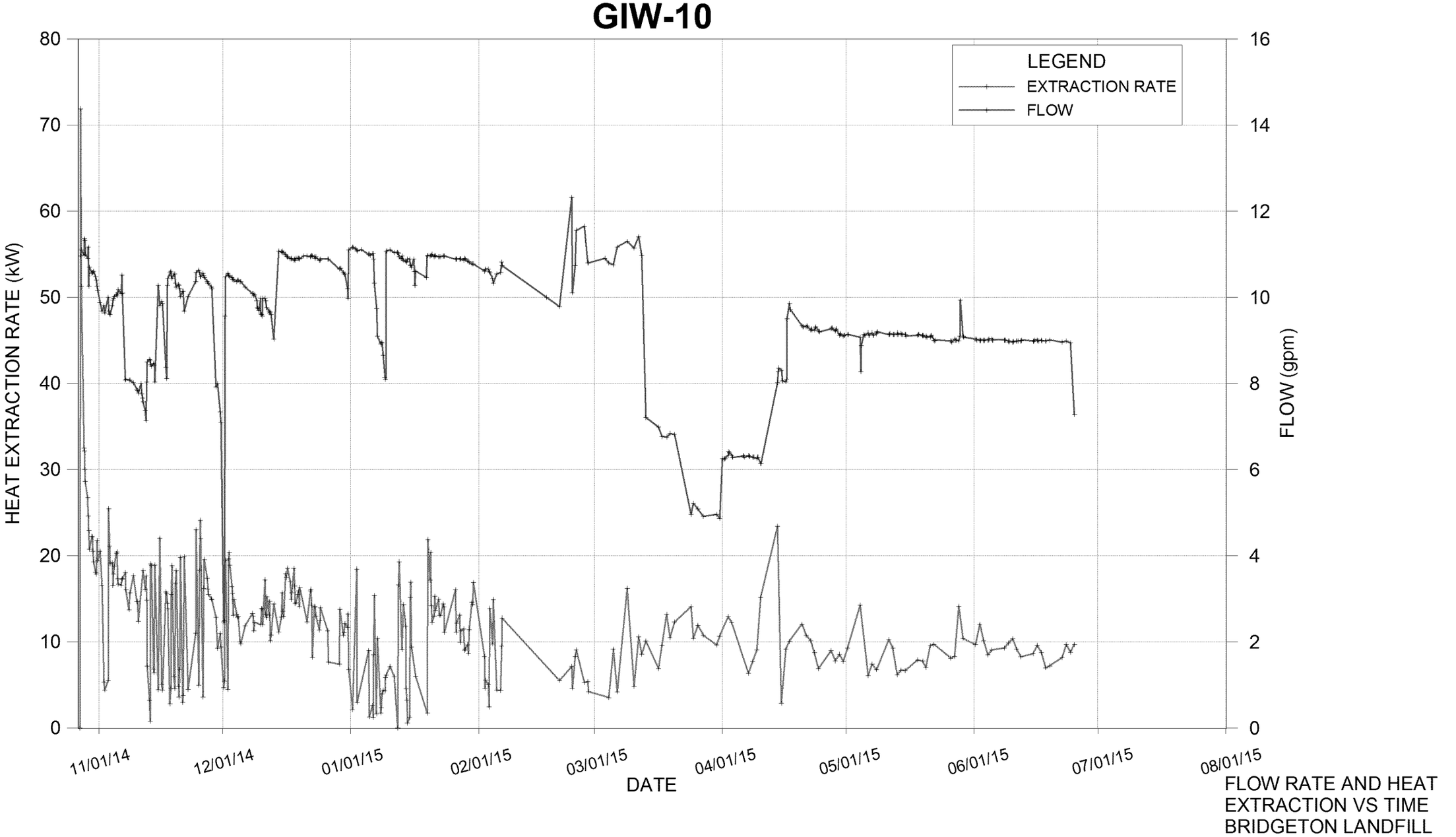
FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL



FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

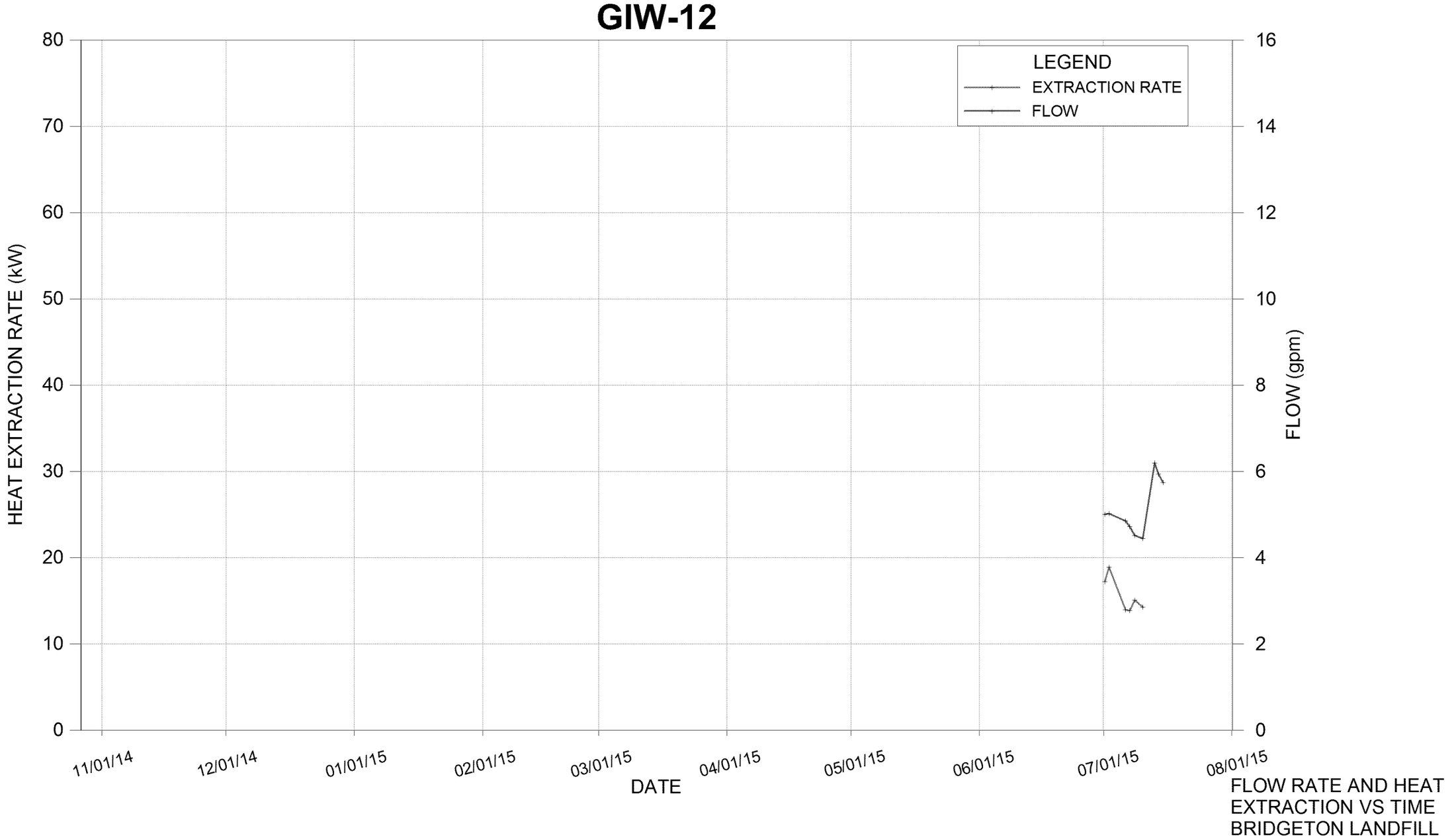


FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL



FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

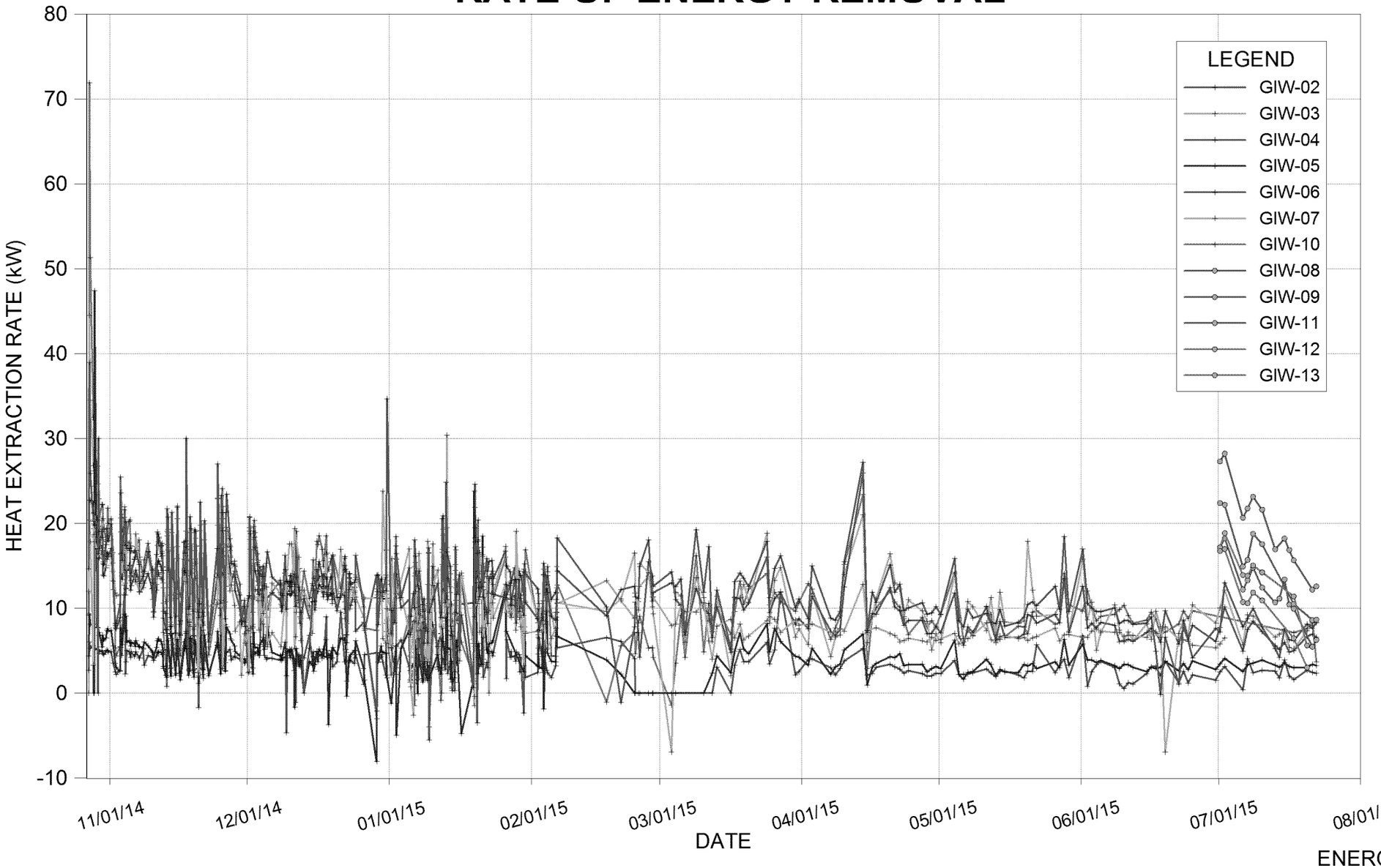
FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL



FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

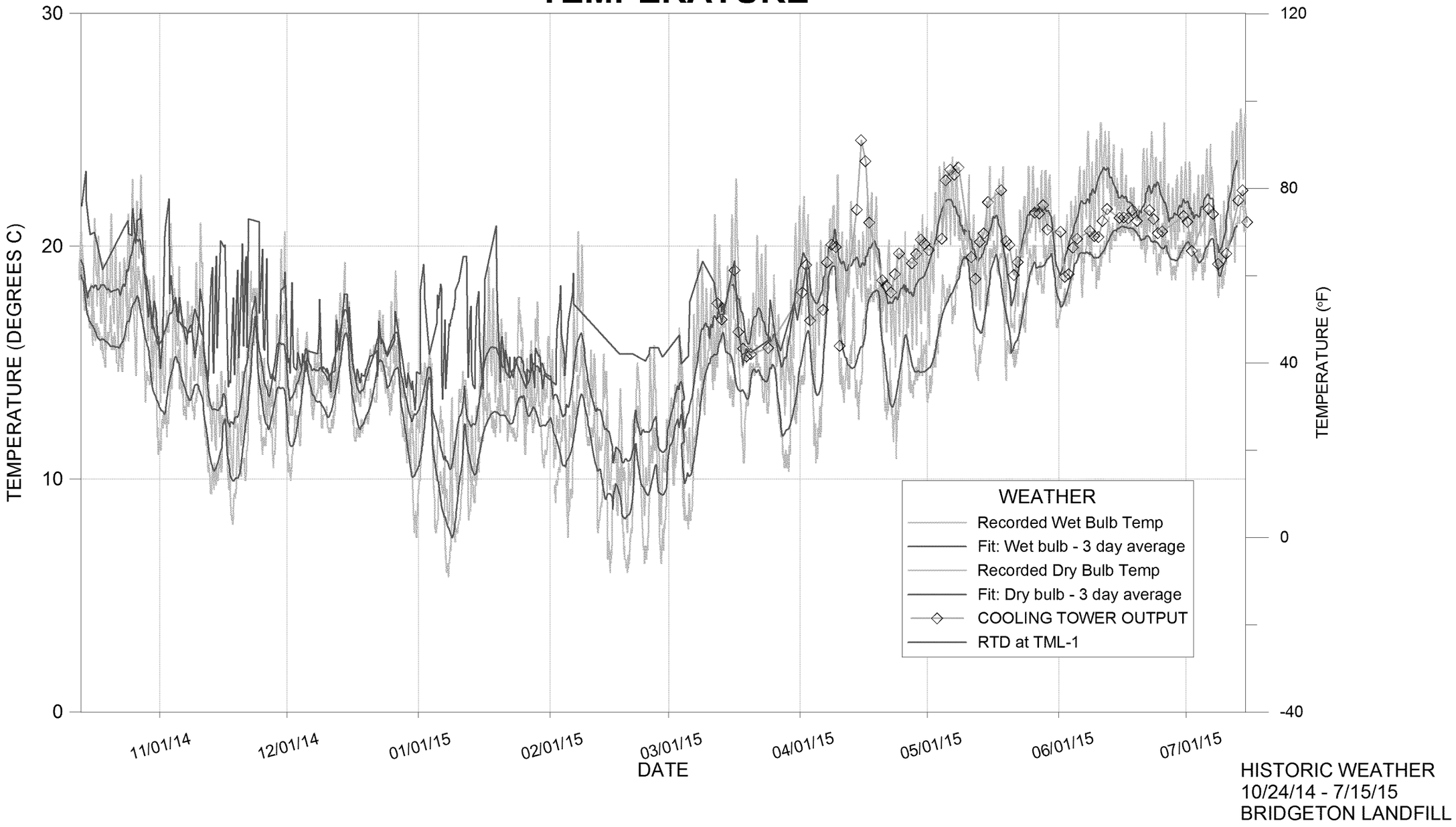
FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL

RATE OF ENERGY REMOVAL



ENERGY REMOVAL RATE
BRIDGETON LANDFILL

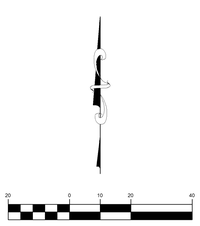
TEMPERATURE



HISTORIC WEATHER
10/24/14 - 7/15/15
BRIDGETON LANDFILL

APPENDIX C – HEAT REMOVAL PILOT STUDY LAYOUT

WLLFOIA4312 - 001 - 0017952



LEGEND

- EXISTING GRADE (2' CONTOUR)
- EXISTING GRADE (10' CONTOUR)
- EXISTING GAS EXTRACTION WELL
- EXISTING TEMPERATURE MONITOR PROBE
- EXISTING HEAT EXTRACTION POINT
- 4" COOLING LOOP INFLUENT PIPING (EXISTING)
- 2" COOLING LOOP INFLUENT PIPING (EXISTING)
- 4" COOLING LOOP EFFLUENT PIPING (EXISTING)
- 2" COOLING LOOP EFFLUENT PIPING (EXISTING)
- TEMPERATURE MONITORING LOCATION
- CHECK VALVE
- FLOW CONTROL VALVE
- FLOWMETERS

NOTES:
1.) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

APPENDIX C

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL EXPANDED HEAT EXTRACTION PILOT STUDY ADDITIONAL HEAT EXTRACTION PTS	Engineering for a Better World FEEZOR ENGINEERING, INC.	MARCH 2015 DESIGNED BY: DMK APPROVED BY: ALK
CURRENT HEAT REMOVAL SYSTEM			DRAWING NO.: **001**
PROJECT NUMBER: BT-059	FILE PATH: C:\Users\DaneDesktop\BT-062 Heat Extraction Services\current System For Aug 4 2015 Report\BT-059-CU-003 (Proposed Cooling Points) As Builts.dwg	REVISION	DATE

APPENDIX D – HEAT REMOVAL SYSTEM

OPERATING LOG

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 10-24-14

Time: 9:00 Am

Actions Taken or Observations:

Electric pump installed, Setting open flow Gpm to 120

9:30 - Pump operational, Main Flow meter Not working. Setting Hz to 50 & Tuning Wells to 10 Gpm.

10:30 - All wells set to 10 Gpm but Giw 4. It could only get 9 Gpm.

13:30 - opening back valve & turning pump to 55 Hz to try to achieve 10 Gpm on Giw 4.

14:00 - Giw 4 will only reach 8.8 Gpm, Setting pump back to 50 Hz & retuning Wells to 10 Gpm.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 10-27-14

Time: 9:00 Am

Actions Taken or Observations:

Flow at wells down to 0-5 Gpm, Increasing pump to 60 Hz & retuning wells to 10 Gpm

1000 - Wells only at 3 to 6 Gpm w/ the back valve completly closed

1200 - Changing bag filters & unclogging the main flow meter to try and improve Gpm.

1300 - flow returns to normal & main flow meter is operational. Pump set to 46 Hz & wells tuned to 10 Gpm.

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BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Welser

Date: 10-28-14

Time: 10:30

Actions Taken or Observations:

The flow to GW 5 cooling point is shut off to observe the rate at which the temperature rises when cooling is removed.

1700- flow is returned to GW 5

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 10-29-14

Time: 9:00

Actions Taken or Observations:

GIW 4 is shut off so the out flow can be inspected for Leachate due to the Low GPM Achieved at GIW 4.

1300- Outflow at GIW 4 is free of leachate, GIW 4 is turned back on.

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BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-6-14

Time: 10:45 Am

Actions Taken or Observations:

Turning off the pump so the bag filters can be changed due to dropping Gpm's.

11:00 Am Pump restarted, Gpm back at 90

~ 17:00 Tuning wells down to 8 Gpm

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BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-11-14

Time: 3:00 pm

Actions Taken or Observations:

- Giw 10 shut down to repair the RTO

- 4:00pm Giw 10 turned back on

- 17:00 Cooling Tower shut off for the night
Due to low temperatures

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-12-14

Time: 13:00

Actions Taken or Observations:

- Cooling Loop shut down so the bag filters can be changed due to a decrease in the GPM at the Pumps flowmeter
The Cooling Tower is shutdown due to near freezing temperatures in the influent line.

- 13:30 Cooling Loop turned back on, GPM - 75.62

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aron Weber

Date: 11-13-14

Time: 9:50

Actions Taken or Observations:

- Cooling tower turned back on due to the influent & effluent temperatures near equalization.

- 17:00 Cooling Tower shut down for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-14-14

Time: 9:00

Actions Taken or Observations:

- Cooling tower turned back on.

- 13:00 Tuning wells back to 10 Gpm, GIW 3 to 12 Gpm

- 15:25 Cooling tower turned off due to Low temp in the Influent Line

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-17-14

Time: 13:00

Actions Taken or Observations:

- Loop & Tower shut down so bag filters can be changed

-13:20 Loop & Tower turned back on.

-17:00 Tower turned off for the night due to Low temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-18-14

Time: 9:30

Actions Taken or Observations:

- Cooling Tower turned back on.
- 17:00 Tower turned off for the night due to Low temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-19-14

Time: 9:30

Actions Taken or Observations:

- Cooling Tower Started

17:00 - Cooling Tower shut off for the night due to freezing temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-20-14

Time: 13:00

Actions Taken or Observations:

- Cooling Tower turned on

- 17:00 Cooling Tower turned off for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 11-21-14

Time: 9:30

Actions Taken or Observations:

- Cooling Tower Started.

- 1500 Cooling Tower turned off for the day

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-24-14

Time: 10:00

Actions Taken or Observations:

- Bag filter changed due to lowered GPM.
- 10:20 Cooling Tower started
- 15:40 Cooling Tower shut off for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aron Weber

Date: 11-25-14

Time: 7:30

Actions Taken or Observations:

- Cooling Tower turned on.

- 16:50 Cooling Tower turned off for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 11-26-14

Time: 7:30

Actions Taken or Observations:

- Cooling Tower turned back on.

- 16:00 Cooling Tower turned off for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 12-1-14

Time: 11:40

Actions Taken or Observations:

- Cooling tower shut off to prep for bag filter replacement.

- 12:30 Bag filters changed & Cooling tower turned back on.

- 17:00 Tower shut off for the night.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 12-2-14

Time: 7:30

Actions Taken or Observations:

- Cooling tower turned on

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Karlas

Date: 12-13-14

Time: 0925

Actions Taken or Observations:

Observed system flow @ approximately 75 gpm. Shut pump down and changed bag filters. Restarted system pump and flow was restored to 97 gpm!

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Karlas

Date: 12/31/14

Time: 11:50 AM

Actions Taken or Observations:

- System flow-meter appeared to be dropping in GPM -
- Bag filters changed and 90+ GPM restored.
- Open Cooling Tower Shut-Off due low ambient temperatures. Prevented use, to avoid any freezing.

To be re-evaluated in the AM 1/2/15

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Brad Vits

Date: 1/2/2014

Time: 08:38 a.m.

Actions Taken or Observations:

- Turned the cooling tower on.

WLLFOIA4312 - 001 - 0017976

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: ~~1/5/15~~ 1/6/15

Time: 11:00am

Actions Taken or Observations:

Turned cooling tower on

WLLFOIA4312 - 001 - 0017977

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: ~~1/5/15~~ 1/6/15

Time: 7:00 pm

Actions Taken or Observations:

- turned cooling tower ~~off~~

WLLFOIA4312 - 001 - 0017978

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/7/15

Time: 6:00 AM

Actions Taken or Observations:

- turned cooling tower on

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/7/15

Time: 11:15 AM

Actions Taken or Observations:

turned cooling tower off

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/12/15

Time: 12:00 PM

Actions Taken or Observations:

Turned cooling tower on.

6 pm - turned cooling tower off.

WLLFOIA4312 - 001 - 0017981

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/13/15

Time: 11 am

Actions Taken or Observations:

11 am - turned cooling tower on

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/14/15

Time: 7:00 AM

Actions Taken or Observations:

7:00 AM - Turned cooling tower off

WLLFOIA4312 - 001 - 0017983

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Adam Fox

Date: 1/15/15

Time: 7:00 AM

Actions Taken or Observations:

Turned Cooling Tower On

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: _____

Date: 1-16-15

Time: Morning

Actions Taken or Observations:

Cooling Tower turned off due to low ambient temperature.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: _____

Date: 1-20-15

Time: Morning

Actions Taken or Observations:

Cooling tower turned back on due to rising ambient temperatures

WLLFOIA4312 - 001 - 0017986

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: _____

Date: 2-1-15

Time: Evening

Actions Taken or Observations:

Cooling tower turned off at the end of the day due to dropping overnight temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: _____

Date: 2-4-15

Time: Morning

Actions Taken or Observations:

Cooling tower turned on due to a higher ambient temperature today

Cooling tower shut off at night due to dropping overnight temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: _____

Date: 2-7-15

Time: Morning

Actions Taken or Observations:

Cooling tower turned back on due to rising ambient temperatures.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 2-9-14

Time: 7:00 Am

Actions Taken or Observations:

Cooling Loop shut down for conversion from Water to Glycol

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Lehn

Date: 2-14-15

Time: _____

Actions Taken or Observations:

Conversion to Closed Loop Glycol System Completed, the Cooling Loop is restarted.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 2-20-15

Time: 8:30

Actions Taken or Observations:

Replaced Leaking Globe Valve on GW 4.

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 2-25-15

Time: 8:00 Am

Actions Taken or Observations:

Cooling Tower turned off for installation of New RTDs in GWs 5, 7, & 10.

9:00 Am Installed fittings on the Basin drain & overflow lines.

10:00 Am Cooling Tower restarted

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Wehn

Date: 3-9-15

Time: 12:20 Am

Actions Taken or Observations:

Cooling Tower Switched from Dry to Wet due to rising ambient temperatures.

WLLFOIA4312 - 001 - 0017994

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 3-11-15

Time: 14:00 pm

Actions Taken or Observations:

Cooling tower shut down so the basin could be emptied & cleaned of accumulated dirt.

17:30 Overflow & Drain lines are finished

18:30 Cooling Tower restarted

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Wilke

Date: 3-12-15

Time: 11:00 Am

Actions Taken or Observations:

GIW 5 shut down so the flow meter can be removed & unclogged

11:25 - GIW 5 restarted & GIW 6 shut down so the flow meter can be removed & unclogged

11:45 - GIW 6 restarted & GIW 2 shut down so a leak can be fixed

12:10 - GIW 2 restarted

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 3-13-15

Time: 9:30 Am

Actions Taken or Observations:

All thermocouple plugs reterminated & corrosion removed w/ a wire brush

10:30 All corrosion removed from RTDs

WLLFOIA4312 - 001 - 0017997

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Weber

Date: 3-23-15

Time: 9:00 AM

Actions Taken or Observations:

- Cooling Loop pump went down between Friday the 20th at 5pm and Monday at 9 Am

- 14:30 Cooling Loop pump back up & running

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Mon Weber

Date: 3-30-15

Time: 9:30 Am

Actions Taken or Observations:

Cooling tower shut off SD filter could be cleaned & reattached

1200 - Cooling tower turned back on.

WLLFOIA4312 - 001 - 0017999

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 4-14-15

Time: 8:00 AM

Actions Taken or Observations:

- Cooling Loop pump went down between Friday, April 10, 2015 at 1:00 pm and monday at 7:30am
- 0745 cooling loop pump back & running

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 5-28-15

Time: 0715

Actions Taken or Observations:

Cooling Tower was not operating,
Tower Discharge Temp was high.
- Turned Tower back on.
- Checked Cooling Tower 1hr later, everything is working fine

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 6-1-15

Time: 0825

Actions Taken or Observations:

Cooling Tower was off Temp reads @ 0825 70.0°
restarted Cooling Tower, rechecked Temp
@ 0900 reads 59.0°

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Erin Looney

Date: 06-25-15

Time: 750

Actions Taken or Observations:

Pump at of cooling tower reading zero flow.
- Still pumping - meter out

* Installed Downhole Heat Extraction piping in GW-8, 9, 11, 12 + 13.
System Down until tommorow.
All ground piping being completed.
Aaron
Kaylar

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Aaron Karlas

Date: 6-30-15

Time: 9:30 AM

Actions Taken or Observations:

- Restarted Heat Extraction System to incorporate operation of additional GWs- 8, 9, 11, 12 + 13.
- Cooling ~~Liquid~~ Air Temperature treated liquid directed to all points. System was balanced to direct approximately 6 GPM to North Row of GWs + 10 GPM to South Row including GW 10.

WLLFOIA4312 - 001 - 0018004

APPENDIX E – QUARTERLY UPDATE (03/31/15 to (06/29/15)

ENGINEERING FOR A BETTER WORLD
FEEZOR
ENGINEERING, INC.

EXPANDED HEAT REMOVAL PILOT STUDY QUARTERLY REPORT

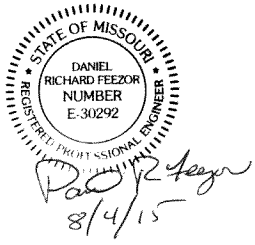
BRIDGETON LANDFILL

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

August 2015

Prepared For:

Bridgeton Landfill, LLC
13570 St. Charles Rock Road
Bridgeton, MO 63044



Prepared By:

Feezor Engineering, Inc.
3405 Hollenberg Drive
Bridgeton, MO 63044

In Association With:

P. J. Carey & Associates, P.C.
587 Valine Way
Sugar Hill, Georgia 30518

WLLFOIA4312 - 001 - 0018006

Expanded Heat Removal Pilot Study Quarterly Report

Bridgeton Landfill, LLC

APPENDICES

WLLFOIA4312 - 001 - 0018007

1 INTRODUCTION

This document is being submitted as a quarterly update regarding the Expanded Heat Removal Pilot Study underway in the South Quarry of the Bridgeton Landfill (BL) in Bridgeton, Missouri. This update was requested by the Missouri Department of Natural Resources (MDNR) in a letter dated September 4, 2014, and includes a summary of work related to the heat removal system and data collected from Temperature Monitoring Probes (TMP), in the vicinity of the heat removal system, during the second quarter of 2015.

The BL completed the installation of an expansion including the addition of five (5) heat extraction points in the neck area of the BL. In a letter dated April 23, 2015, the MDNR approved the retrofit of five (5) additional Gas Interceptor Wells (GIW-8, -9, -11, -12 and -13) with heat removal technology. The BL submitted a response to MDNR in a letter dated May 22, 2015. The heat removal expansion was completed and operational on June 30, 2015.

The following discussion includes a summary of activities completed and data collected in the second quarter of 2015 regarding the Heat Removal System Pilot Study underway at the Bridgeton Landfill (BL). This update includes presentation of in-waste temperature measurements (**Appendix Q2-A)** and summary operational activities and physical modifications completed during the second quarter of 2015.

2 SYSTEM OPERATION

The heat extraction system operated consistently during the second quarter of 2015. The system was operated with minimal operational changes. The only notable down time during the reporting quarter was pursuant to the installation of the heat removal system expansion (June 25th, 2015 to June 30th, 2015). The heat removal system expansion included the expansion of heat removal points to include GIW-8, -9, -11, -12 and -13. The expansion was installed and fully operational on June 30, 2015. As-built drawings (Expanded Heat Removal Pilot Study Additional Heat Removal Points As-Builts) of the system expansion are being submitted as part of the pilot study initial report, concurrently with this document.

3 DATA SUMMARY

The collection of in-waste temperature measurements have been obtained weekly during the second quarter of 2015 as part of the heat removal pilot study and are presented in **Appendix Q2-A** . The measurements of temperature have rendered relatively stable results over the past quarter. The results continue to show a significant reduction in heat north of the respective heat removal elements compared to the temperatures prior to heat removal.

WLLFOIA4312 - 001 - 0018008

4 SUMMARY OF FINDINGS

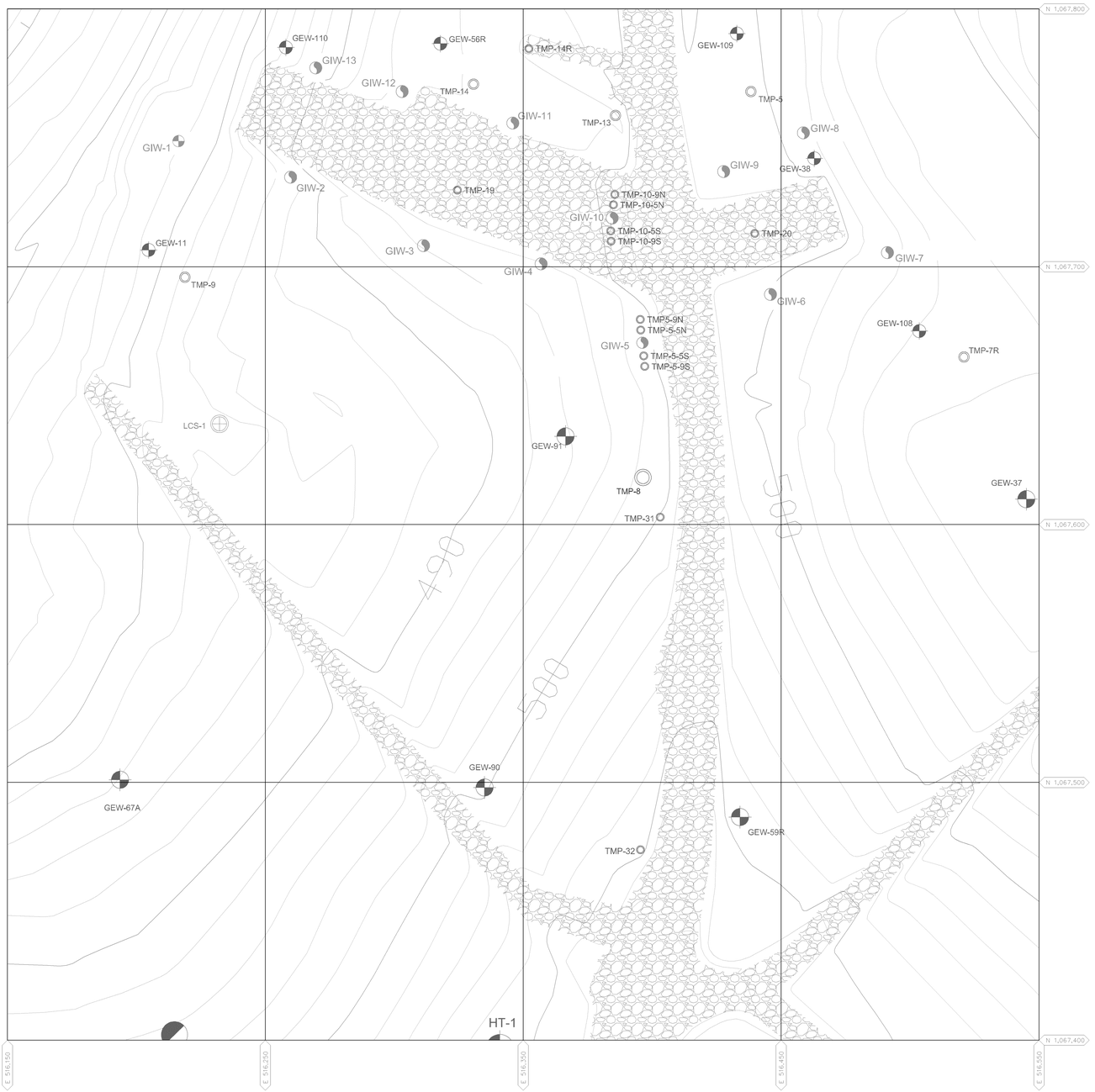
The in-waste temperature measurements, for thermocouples near heat extraction elements, appear to be nearing a steady condition at the end of the second quarter of 2015. However, it is expected that the recent commissioning of GIW -8, -9, -11, -12 and -13 will result in near-term heat distribution changes. The heat removal elements show a significant temperature reduction north of the respective element. The heat removal elements have shown a nominal to moderate temperature reduction in the local temperatures to the south. The TMP graphs show minimal change during the second quarter of 2015.

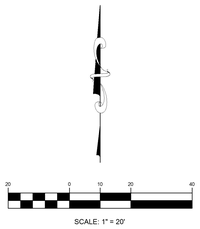
As noted previously, the installation and operation of the additional heat removal points, GIW-8, -9, -11, -12 and -13, commenced on the last day of the quarter. Additional operation and associated data collection would be needed to evaluate the effect the additional points have on the in-waste temperatures and other associated heat removal variables.

WLLFOIA4312 - 001 - 0018009

APPENDIX Q2-A – TEMPERATURE MONITOR PROBE GRAPHS AND LAYOUT MAP

SECOND QUARTER 2015





LEGEND

- EXISTING GRADE (2' CONTOUR)
- 500 EXISTING GRADE (10' CONTOUR)
- EXISTING GAS EXTRACTION WELL
- EXISTING GAS INTERCEPTOR WELL
- EXISTING TEMPERATURE MONITORING PROBE
- AS-BUILT HEAT EXTRACTION AT GAS INTERCEPTOR WELL
- AS-BUILT TEMPERATURE MONITORING PROBE

TMP INSTALLATION			
ID	Northing	Easting	Depth (ft)
TMP-19	1067729.43	516324.34	140
TMP-14R	1067784.62	516352.17	140
TMP-20	1067712.59	516439.87	140
TMP-5-9S	1067661.16	516397.18	100
TMP-5-5S	1067665.2	516396.79	100
TMP-5-5N	1067675.28	516395.69	100
TMP-5-9N	1067679.41	516395.37	100
TMP-10-9S	1067709.77	516384.13	100
TMP-10-5S	1067713.85	516384	100
TMP-10-5N	1067723.9	516384.95	100
TMP-10-9N	1067727.77	516385.53	100
TMP-31	1067602.84	516403.11	192.96
TMP-32	1067474.00	516395.36	205.2

NOTES:
1.) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

BRIDGETON LANDFILL, LLC
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

2014 TEMPERATURE MONITORING PROBE INSTALLATION AS-BUILT DRAWINGS

FEEZOR ENGINEERING, INC.
Engineering for a Better World

JANUARY 2015
DESIGNED BY: AMR
APPROVED BY: ALK

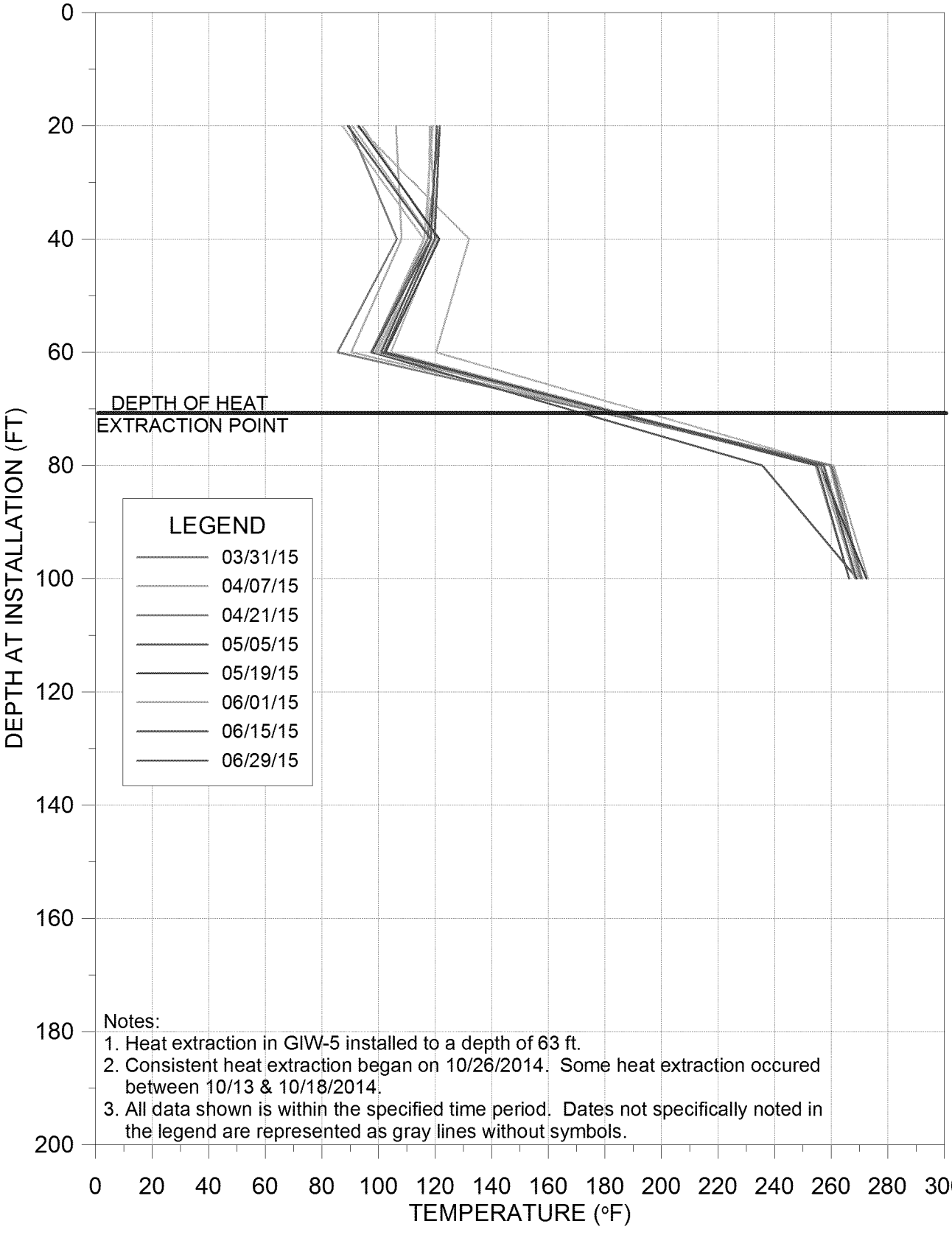
DRAWING NO.: 00¶

TMP INSTALLATION PLAN VIEW

PROJECT NUMBER: BT-045 | FILE PATH:

REVISION | DATE

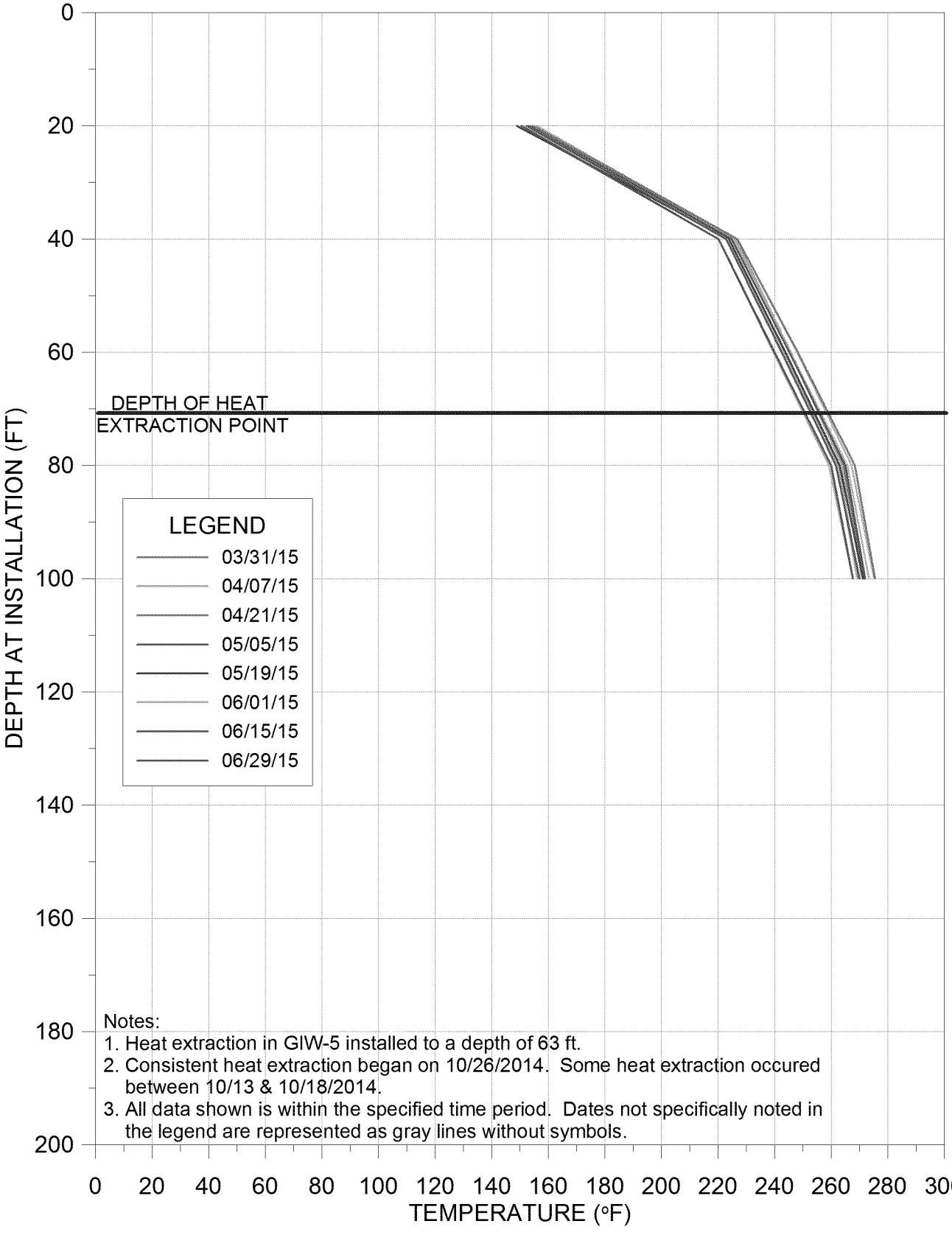
TMP-5-5N



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

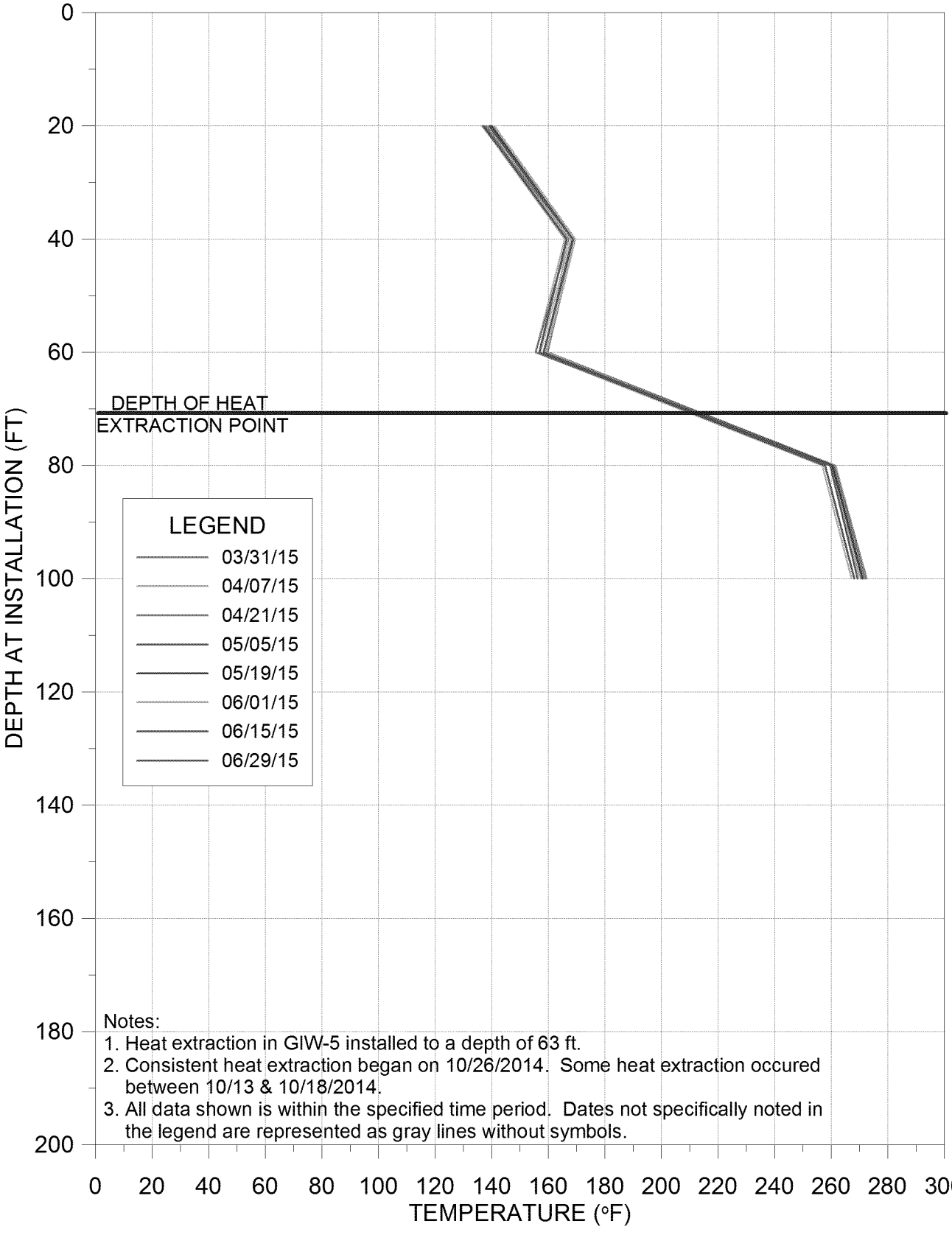
WLLFOIA4312 - 001 - 0018012

TMP-5-5S



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

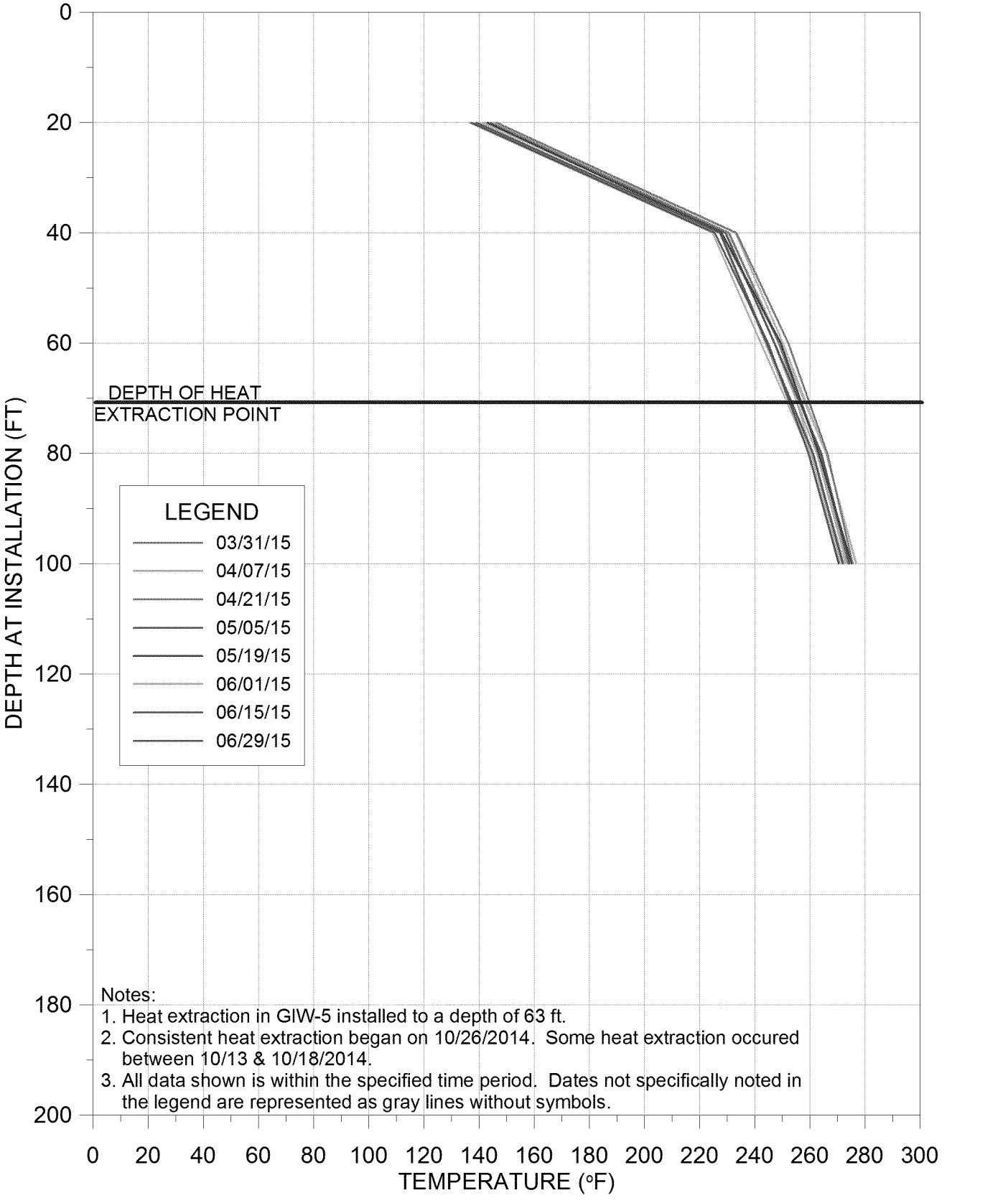
TMP-5-9N



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0018014

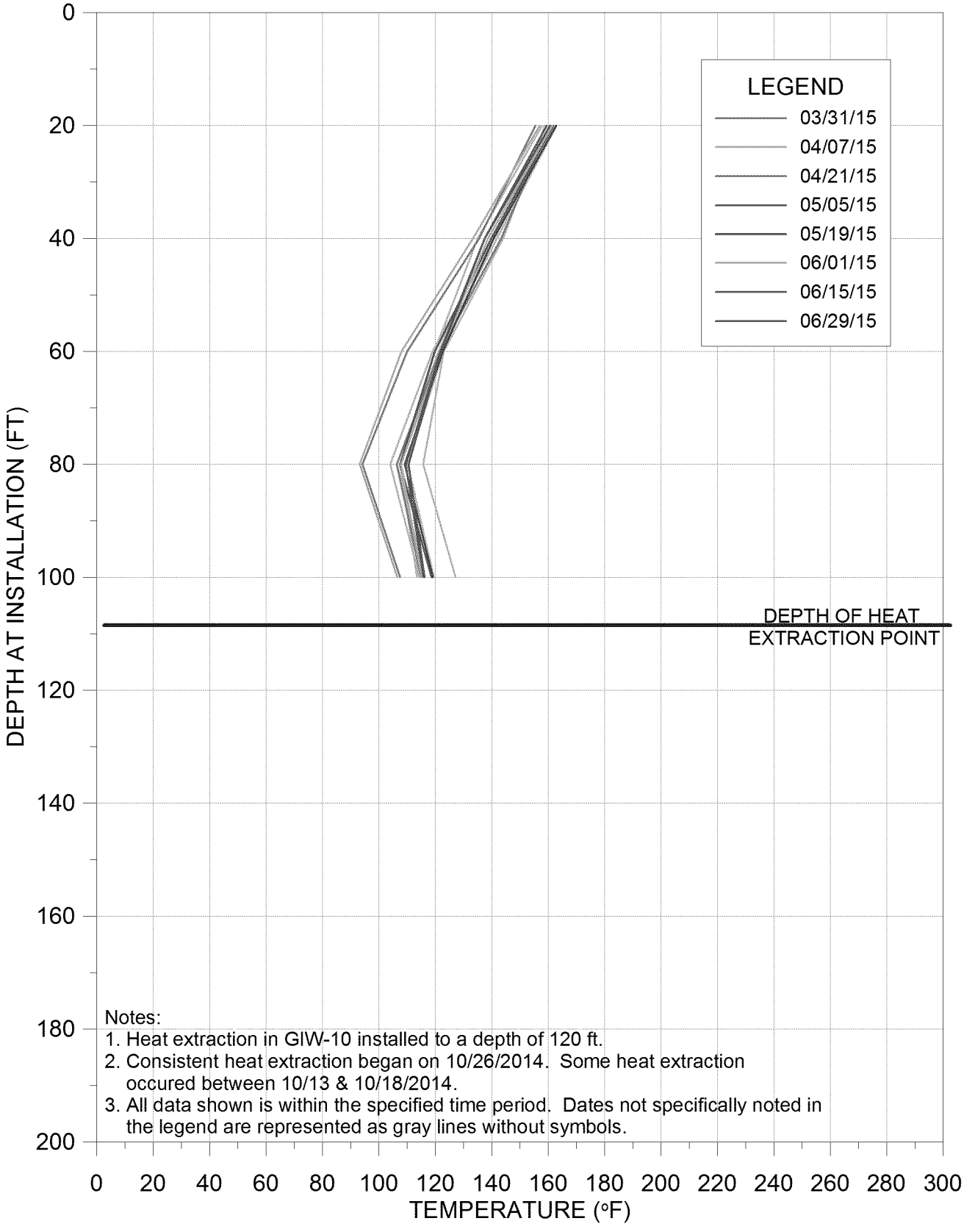
TMP-5-9S



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0018015

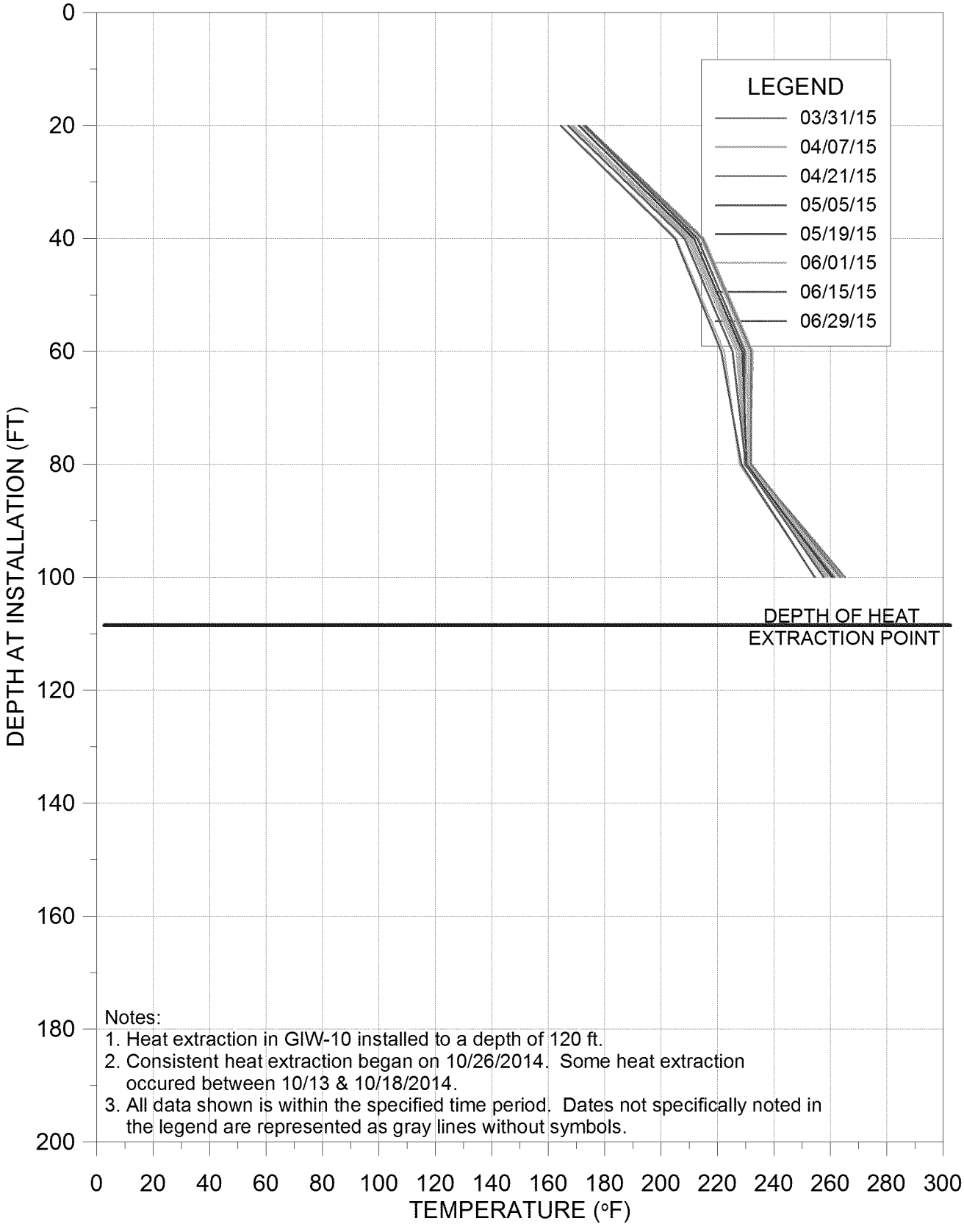
TMP-10-5N



Notes:
1. Heat extraction in GIW-10 installed to a depth of 120 ft.
2. Consistent heat extraction began on 10/26/2014. Some heat extraction occured between 10/13 & 10/18/2014.
3. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.

TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

TMP-10-5S



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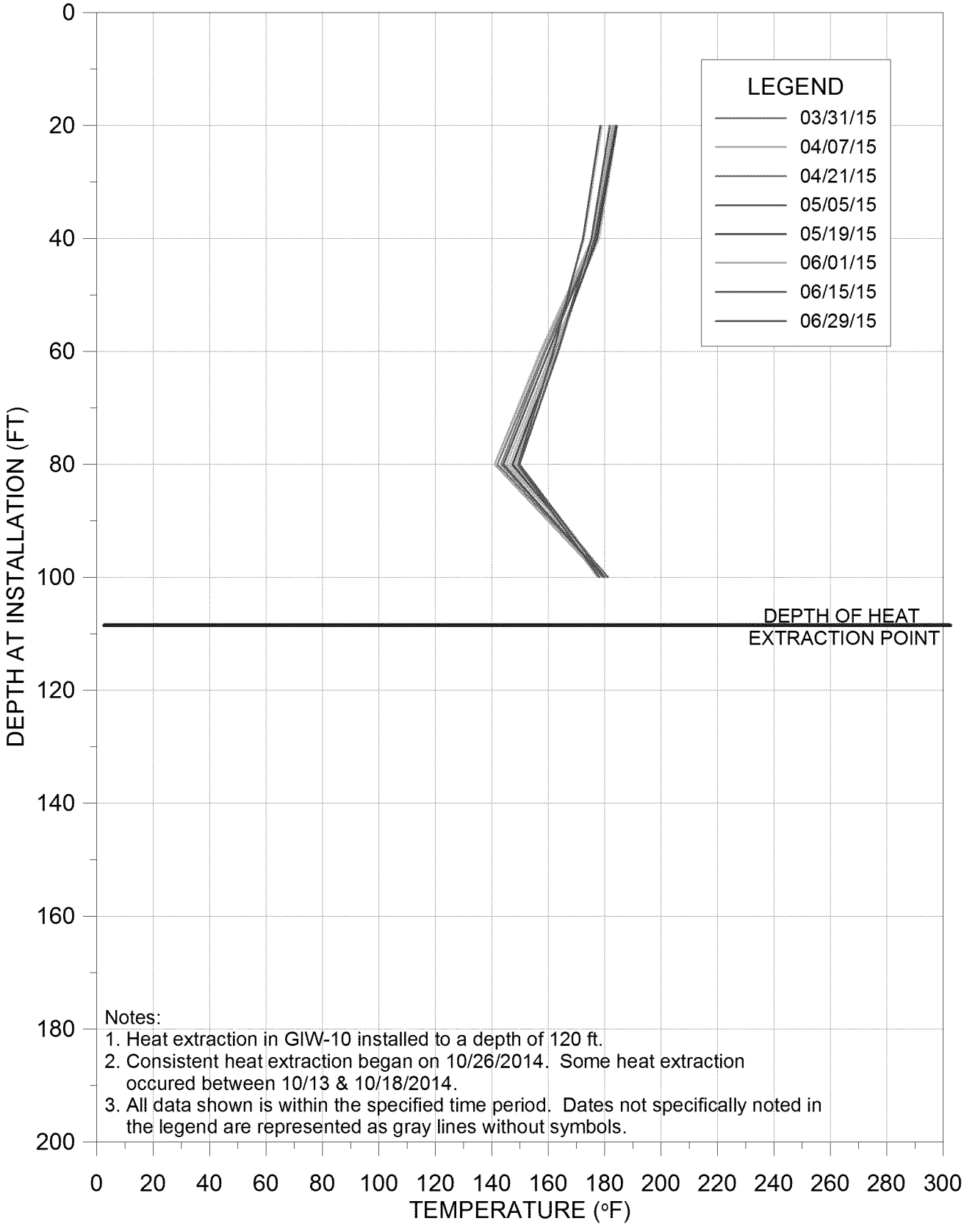
TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

TMP-10-9N



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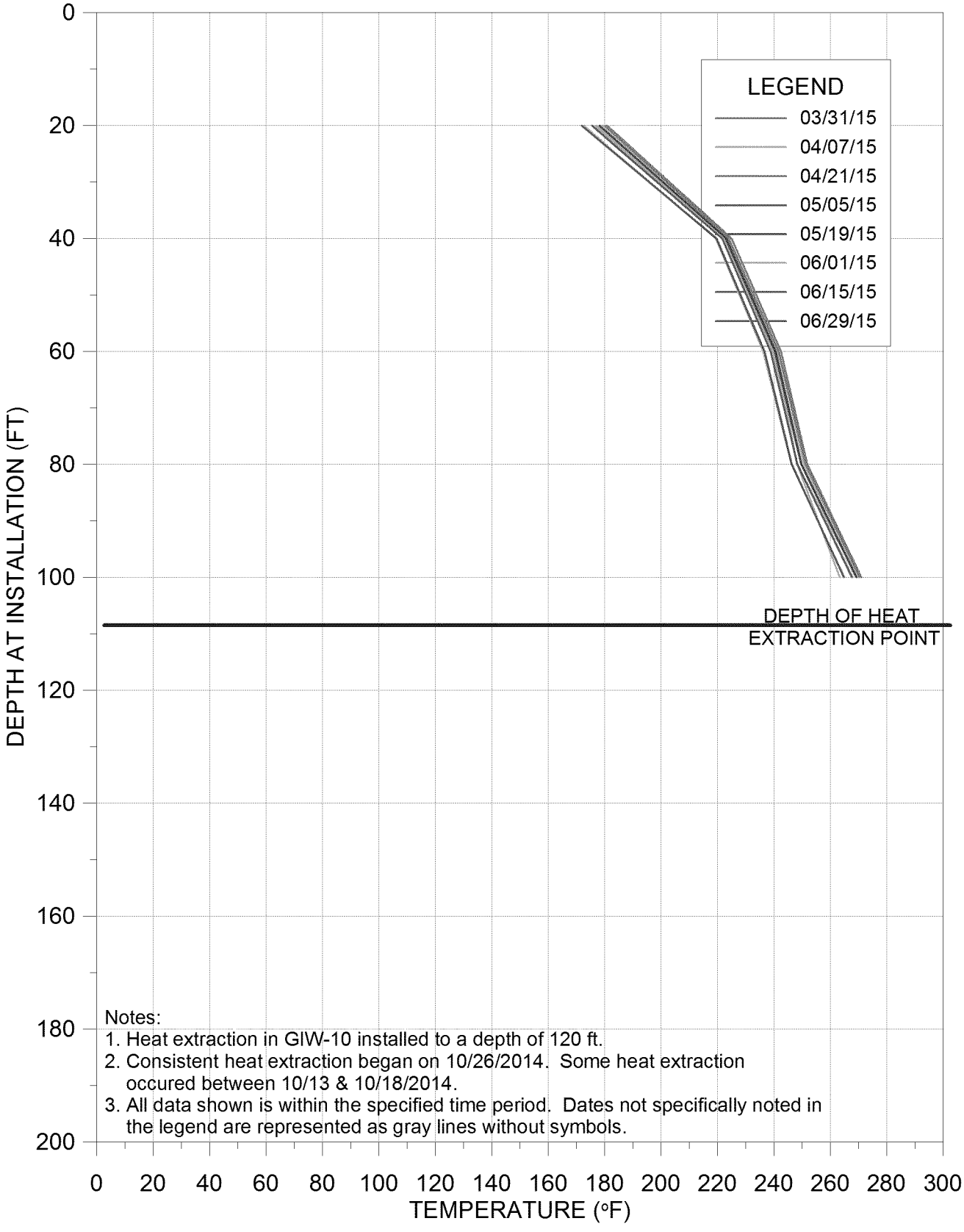
3. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.

TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

TMP-10-9S

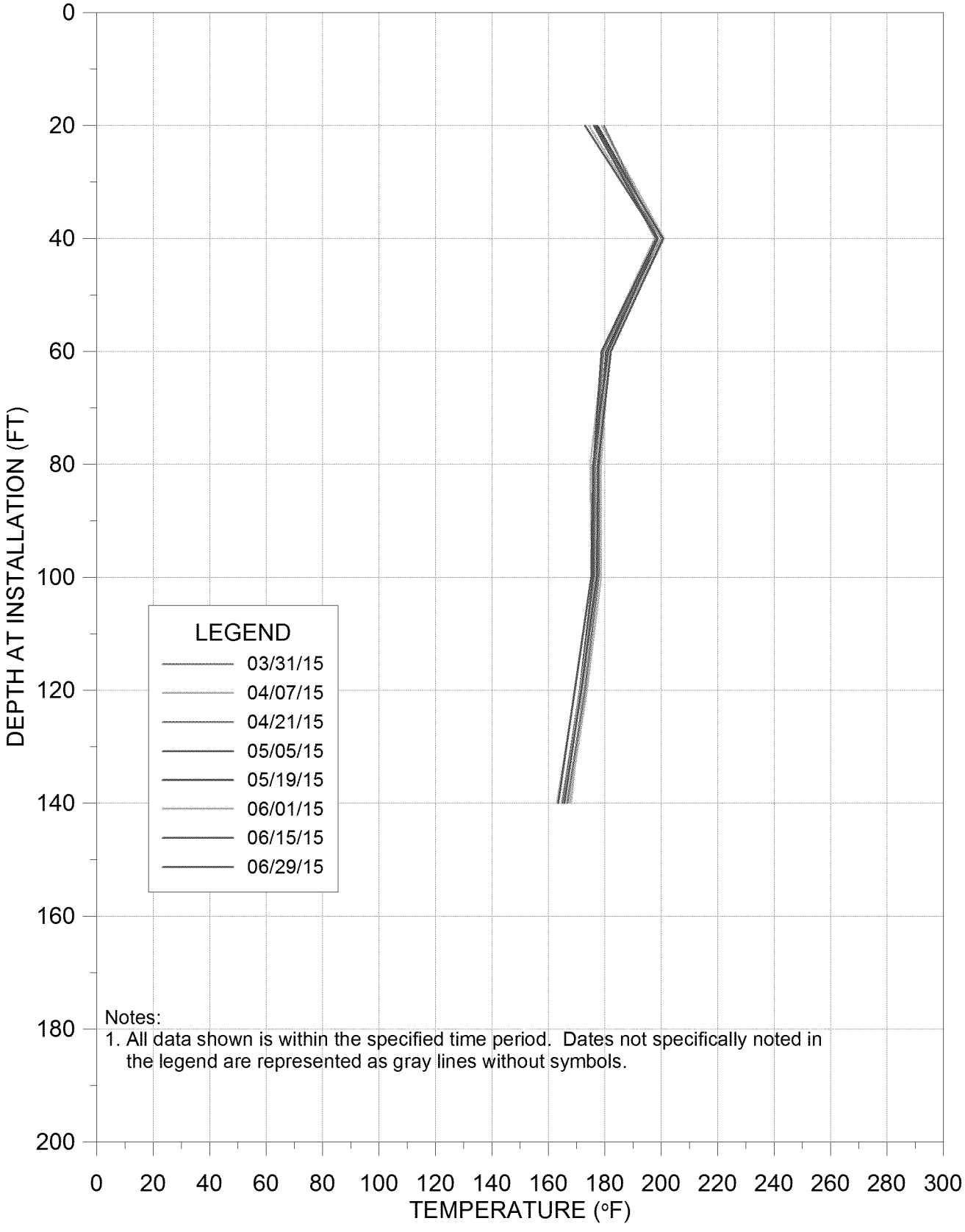


Notes:
1. Heat extraction in GIW-10 installed to a depth of 120 ft.
2. Consistent heat extraction began on 10/26/2014. Some heat extraction occured between 10/13 & 10/18/2014.
3. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.

TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

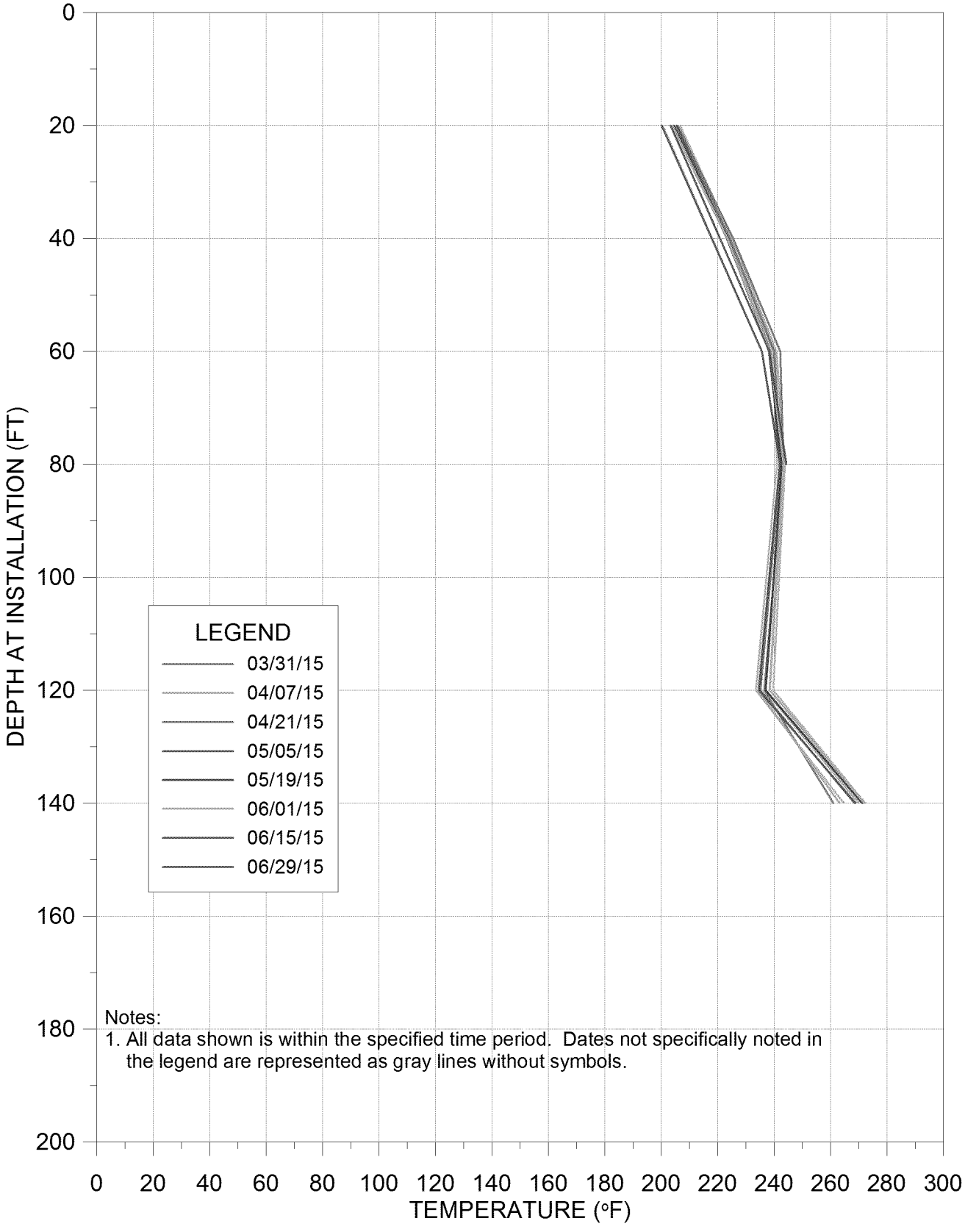
WLLFOIA4312 - 001 - 0018019

TMP-14R



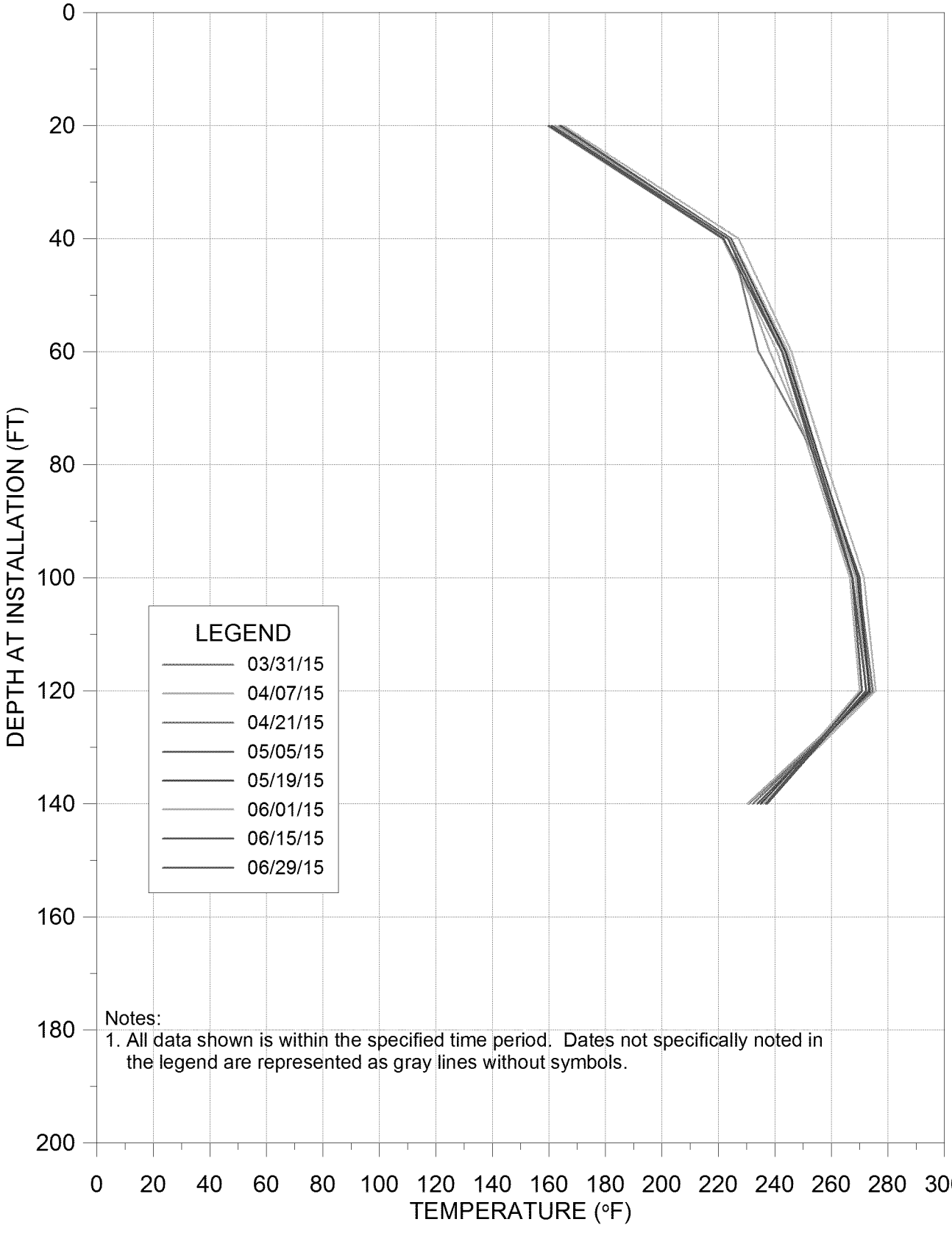
TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

TMP-19



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

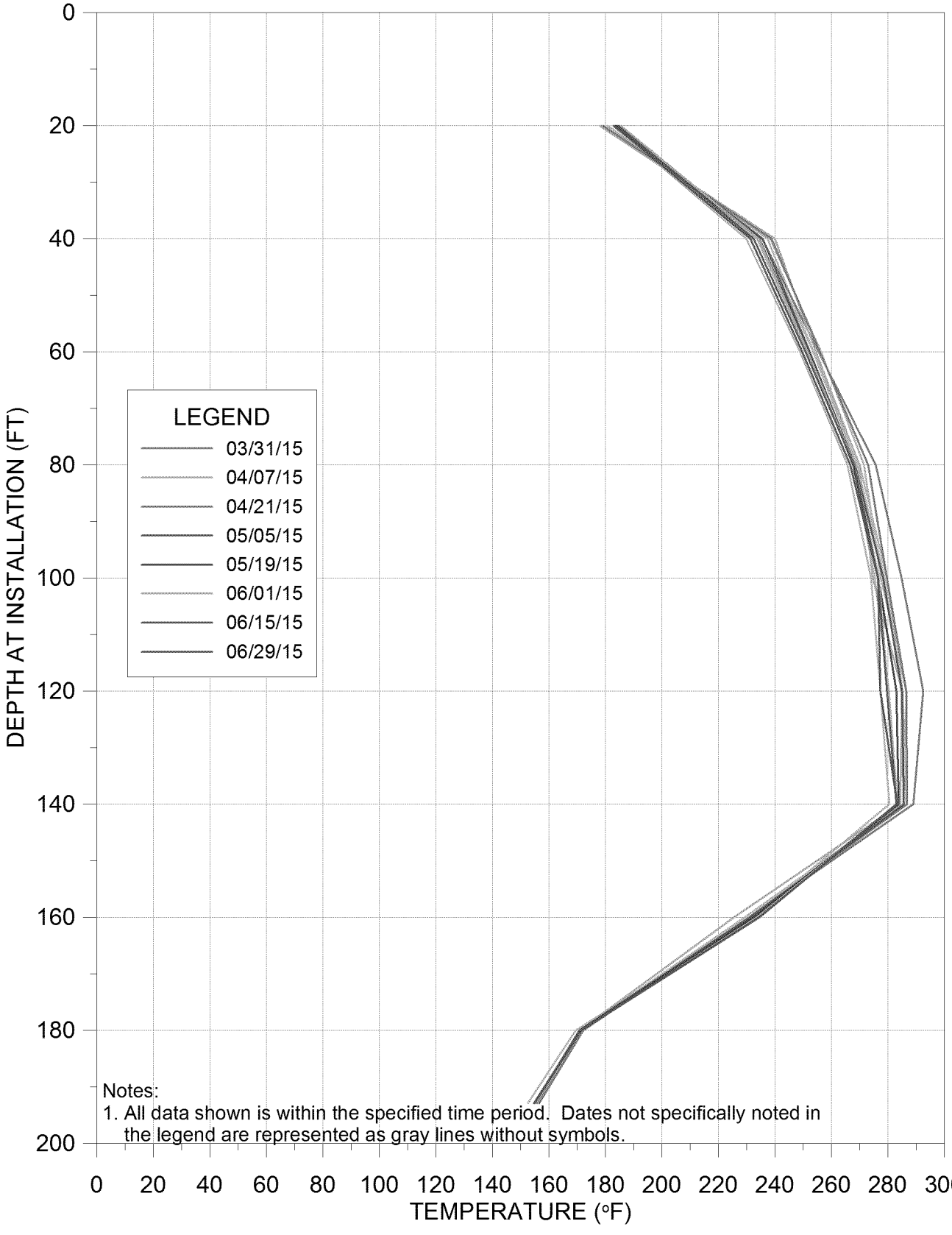
TMP-20



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

WLLFOIA4312 - 001 - 0018022

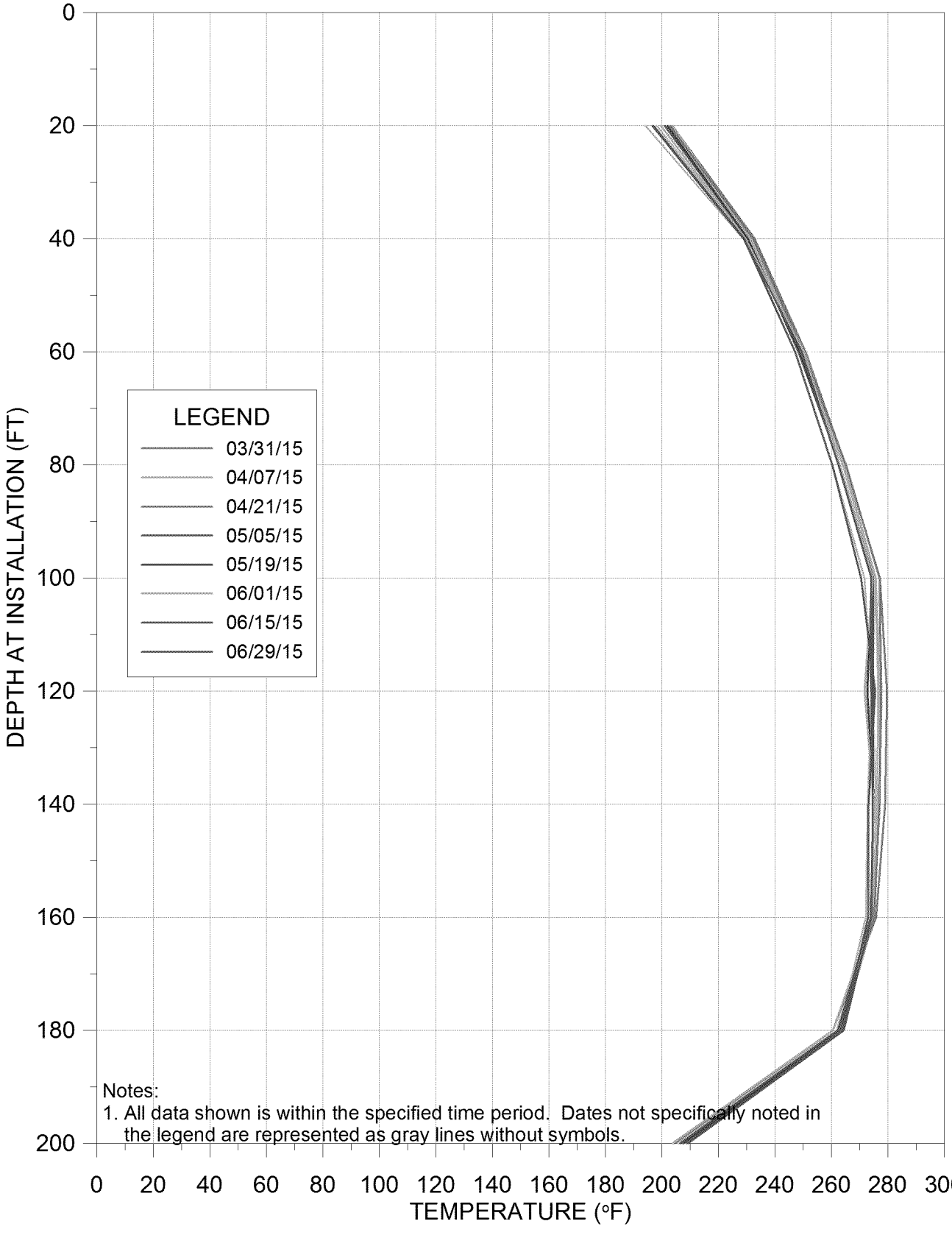
TMP-31



Notes:
1. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.

TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

TMP-32



TEMPERATURE VS DEPTH
03/31/15 - 06/29/15
BRIDGETON LANDFILL

APPENDIX F – HEAT REMOVAL POINT AS-BUILT DRAWINGS

(GIW-8, -9, -11, -12 AND -13)

CONSTRUCTION DRAWINGS FOR

EXPANDED HEAT REMOVAL PILOT STUDY ADDITIONAL HEAT REMOVAL POINTS AS-BUILTS BRIDGETON LANDFILL

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

JUNE 2015

PREPARED FOR:
BRIDGETON LANDFILL, LLC.

Engineering for a Better World
FEEZOR ENGINEERING, INC.

3405 HOLLENBERG DRIVE
BRIDGETON, MO 63044
TEL. (314) 736-5794

P. J. Carey & Associates, P.C.
SPECIALIZING IN GEOTECHNICS, HYDROGEOLOGY AND WASTE MANAGEMENT
"Services for your bottom line"

5878 VALINE WAY
SUGAR HILL, GA 30518
TEL. (678) 482-5193
FAX. (866) 845-3898

INDEX OF DRAWINGS

STATE OF MISSOURI
AARON L KARLAS
NUMBER PE-2014035807
PROFESSIONAL ENGINEER

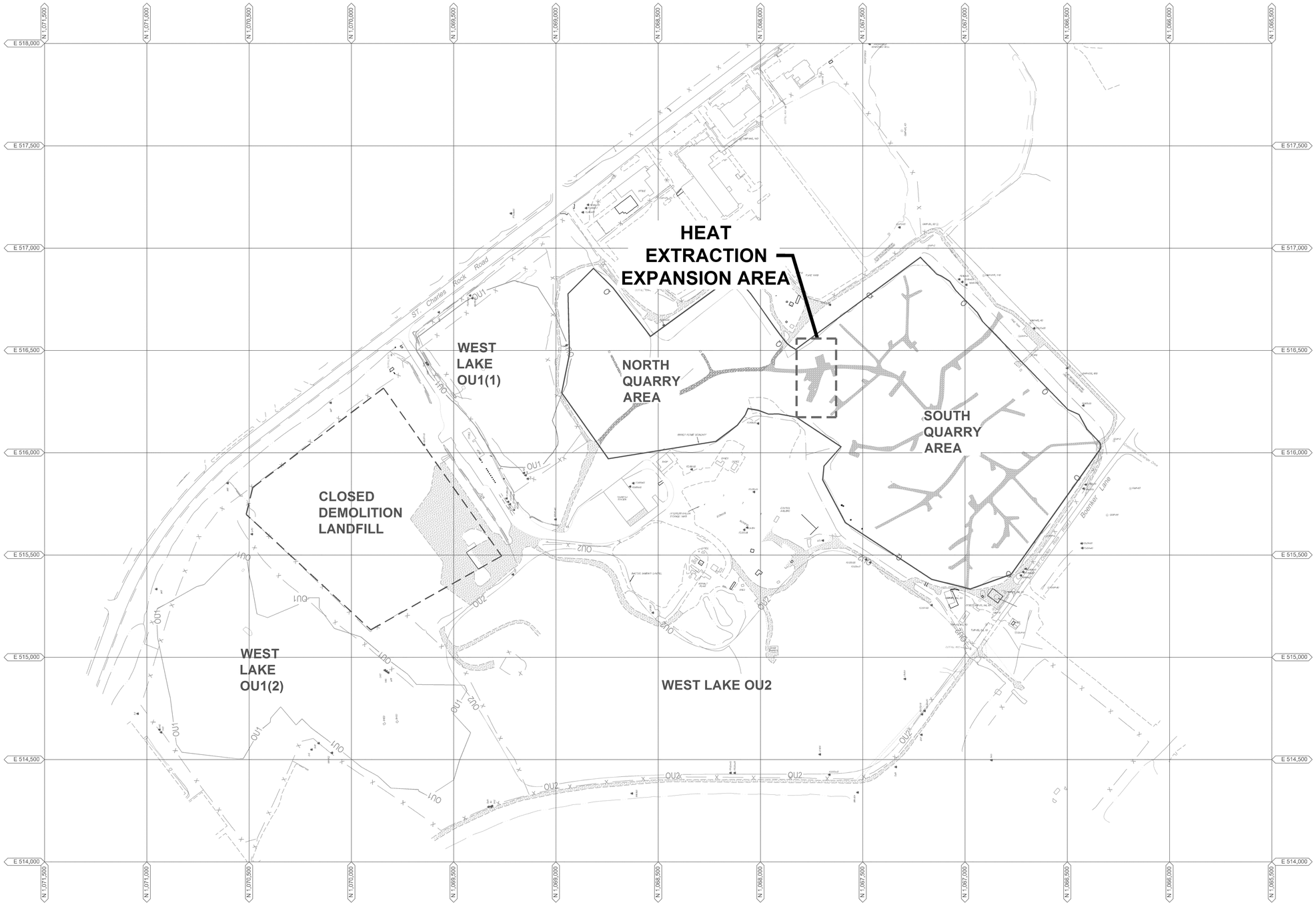
8/4/15

Aaron L. Karlas, P.E.

MO No: PE-2014035807 Date

CHANGES TO THIS PLAN/DRAWING SET REQUIRE WRITTEN APPROVAL BY FEI.

C:\Users\aaron\Desktop\Cad Work\Heat Extraction Expansion\BT-059-CD-001 (Title Sheet) AS-BUILTS.dwg

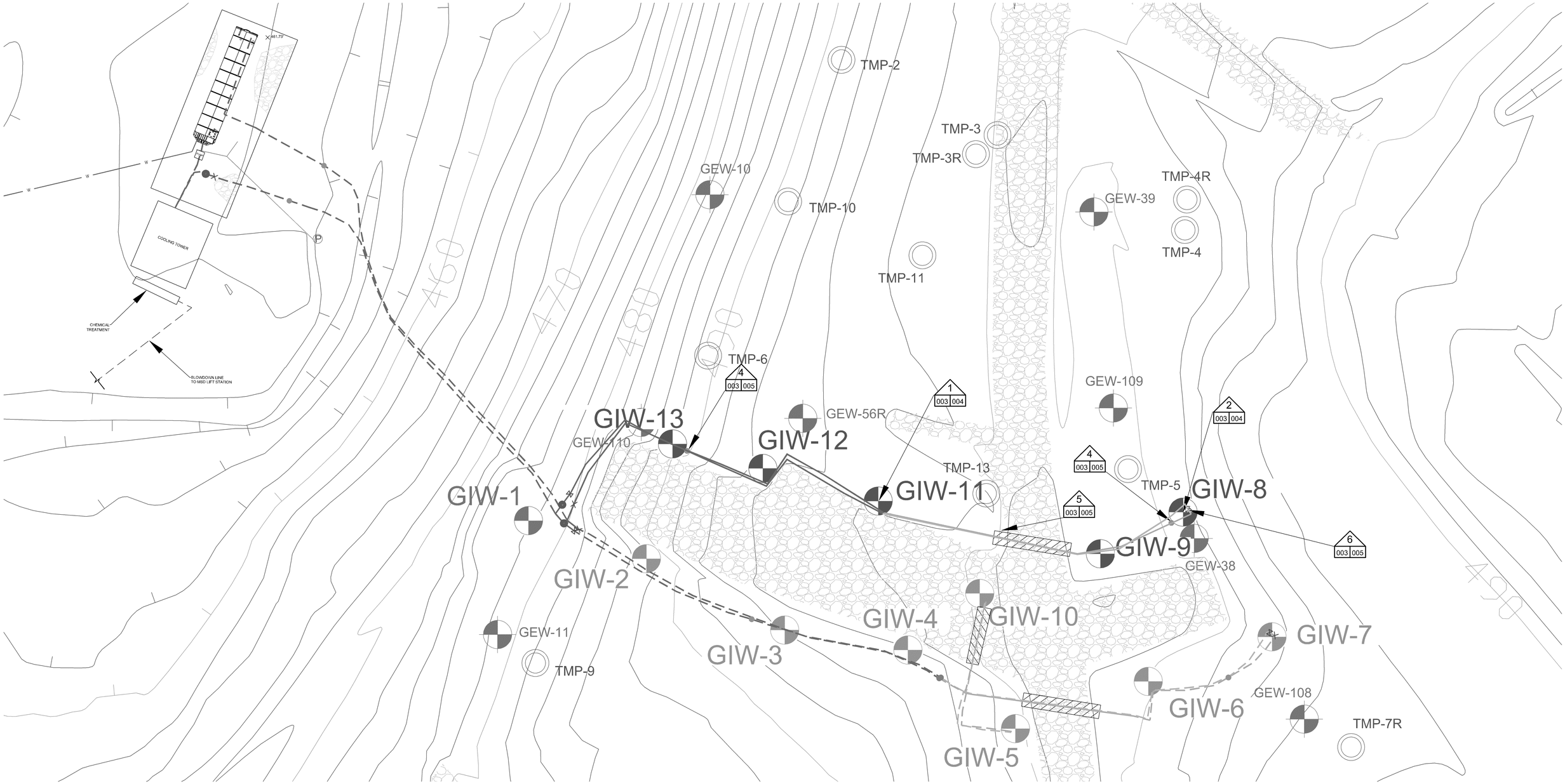


LEGEND

SOLID WASTE BOUNDARY

0 200 400 Feet

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL EXPANDED HEAT EXTRACTION PILOT STUDY ADDITIONAL HEAT EXTRACTION PTS	FEEZOR ENGINEERING, INC. Engineering for a Better World	JULY 2015 DESIGNED BY: DMK APPROVED BY: ALK	DRAWING NO.: 002
FULL SITE PLAN VIEW				
PROJECT NUMBER: BT-059 | FILE PATH:			REVISION | DATE	



LEGEND

- EXISTING GRADE (2' CONTOUR)
- EXISTING GRADE (10' CONTOUR)
- EXISTING GAS EXTRACTION WELL
- EXISTING TEMPERATURE MONITOR PROBE
- EXISTING HEAT EXTRACTION POINT
- AS-BUILT HEAT EXTRACTION POINT
- 4" COOLING LOOP INFLUENT PIPING (AS-BUILT)
- 2" COOLING LOOP INFLUENT PIPING (AS-BUILT)
- 4" COOLING LOOP EFFLUENT PIPING (AS-BUILT)
- 2" COOLING LOOP EFFLUENT PIPING (AS-BUILT)
- 4" COOLING LOOP INFLUENT PIPING (EXISTING)
- 2" COOLING LOOP INFLUENT PIPING (EXISTING)
- 4" COOLING LOOP EFFLUENT PIPING (EXISTING)
- 2" COOLING LOOP EFFLUENT PIPING (EXISTING)
- TEMPERATURE MONITORING LOCATION
- CHECK VALVE
- FLOW CONTROL VALVE
- FLOWMETERS

20 0 10 20 40

SCALE: 1" = 20'

NOTES:
1.) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

BRIDGETON LANDFILL, LLC
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

BRIDGETON LANDFILL
EXPANDED HEAT EXTRACTION
PILOT STUDY
ADDITIONAL HEAT EXTRACTION PTS

Alternative Heat Extraction Expansion

FEEZOR ENGINEERING, INC.
Engineering for a Better World

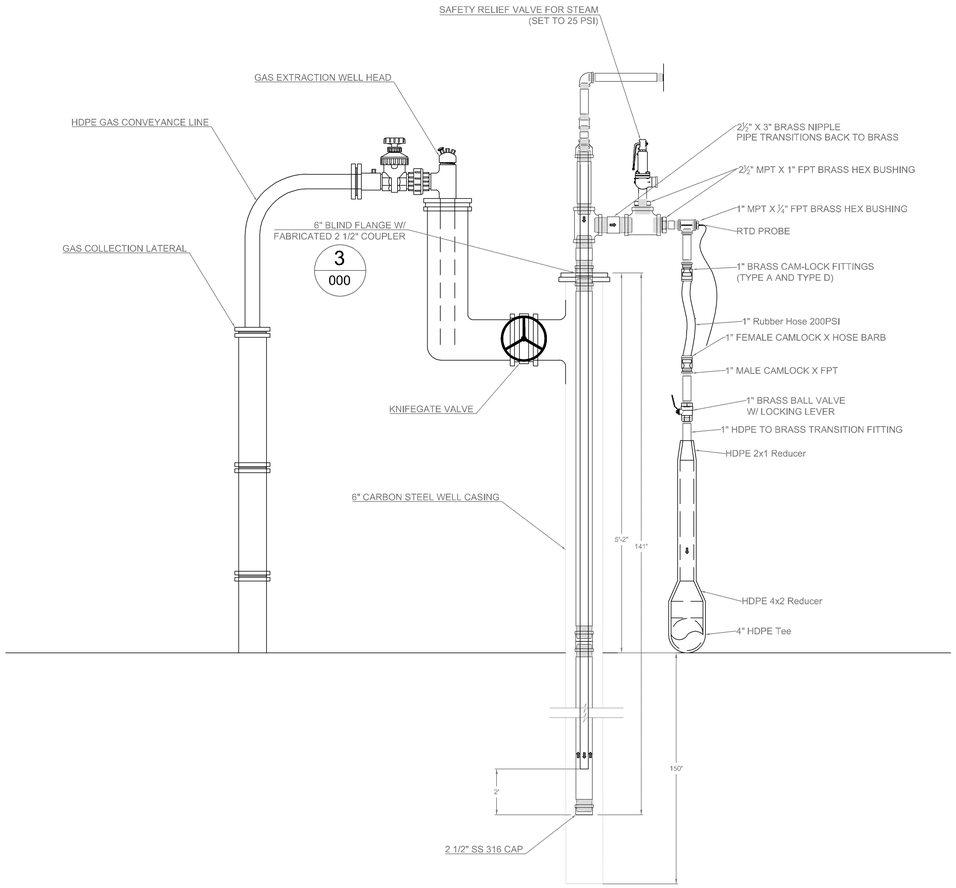
JULY 2015
DESIGNED BY: DMK
APPROVED BY: ALK

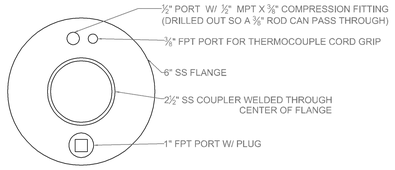
DRAWING NO.:
003

PROJECT NUMBER: BT-059 | FILE PATH: C:\Users\acord\Desktop\Gas Work\Heat Extraction Expansion\BT-059-GD-003 (Proposed Cooling Points) As Built.dwg

REVISION | DATE

WLLFOIA4312 - 001 - 0018028

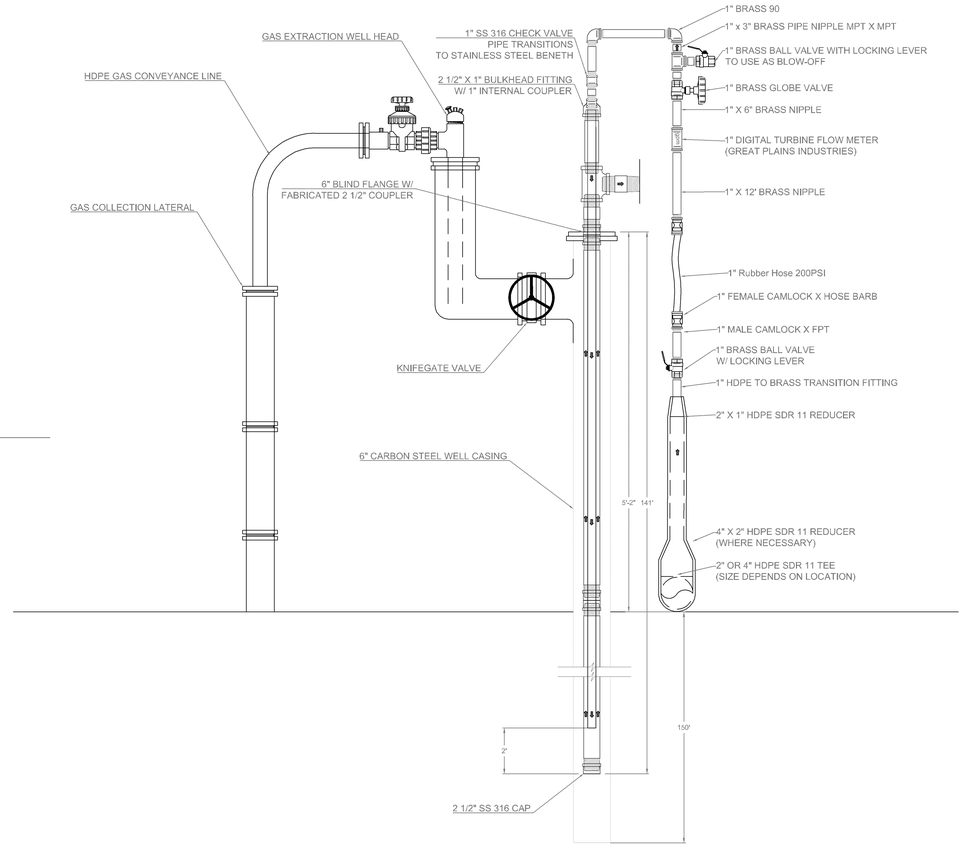




3
004 | 004

6" SS FLANGE

NTS



1
003 | 004

HEAT EXTRACTION POINT EFFLUENT LINE (AS-BUILT)

NTS

NOTE: DETAIL APPLICABLE TO GIW 8, 9, 11, 12 AND 13

2
003 | 004

HEAT EXTRACTION POINT INFFLUENT LINE (AS-BUILT)

NTS

NOTE: DETAIL APPLICABLE TO GIW 8, 9, 11, 12 AND 13

Designation	Northing	Easting	Top of Flange Elevation	Depth of HE Point Installation
GIW-13	1,067,776.24	516,269.87	491.76	120'
GIW-12	1,067,765.91	516,303.44	498.87	120'
GIW-11	1,067,753.68	516,346.17	499.40	120'
GIW-9	1,067,734.23	516,427.25	504.95	115'
GIW-8	1,067,748.47	516,456.39	501.63	120'
Temperature Monitoring Location North 1	1,067,777.63	516,268.20		
Temperature Monitoring Location North 2	1,067,749.53	516,455.44		

BRIDGETON LANDFILL, LLC
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

BRIDGETON LANDFILL
EXPANDED HEAT EXTRACTION
PILOT STUDY
ADDITIONAL HEAT EXTRACTION PTS

Engineering for a Better World
FEEZOR ENGINEERING, INC.

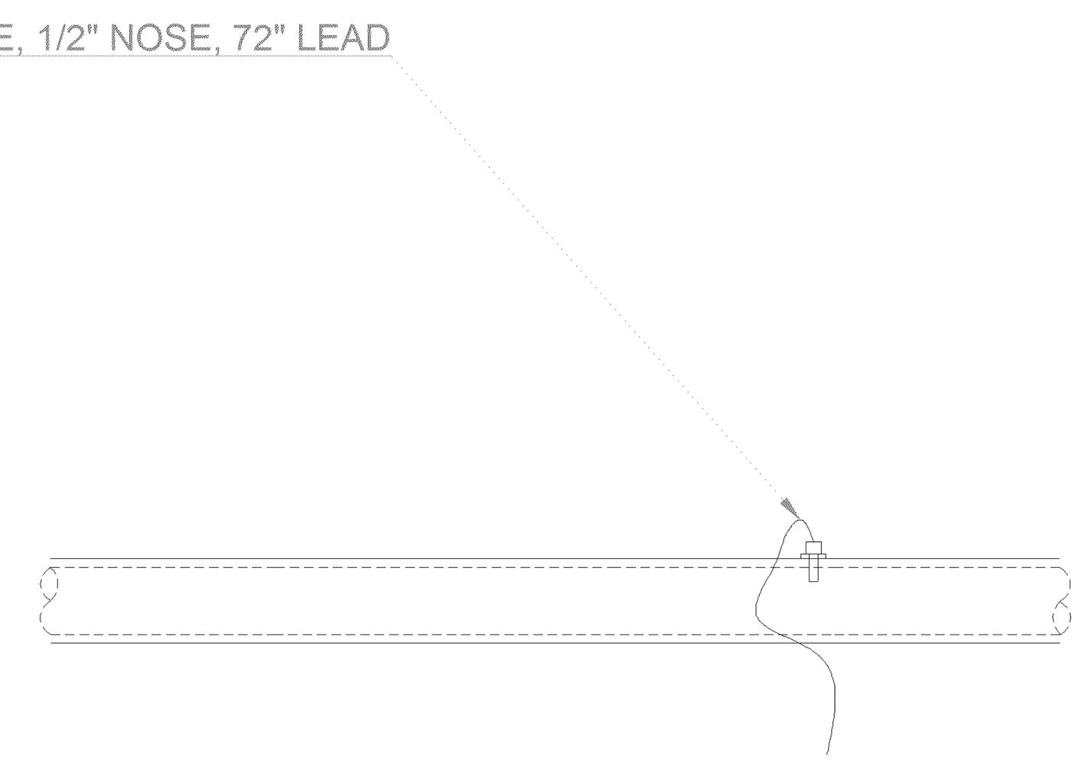
JULY 2015
DESIGNED BY: DMK
APPROVED BY: ALK

DRAWING NO.:
004

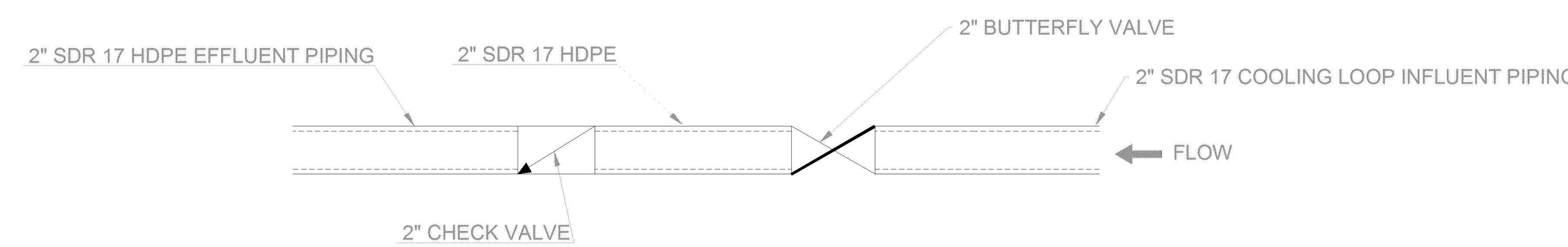
HEAT EXTRACTION SYSTEM
INSTALLATION - DETAILS

PROJECT NUMBER: BT-059 | FILE PATH: C:\Users\bsaxe\Dropbox\Esri Work\Heat Extraction Expansion\BT059\DWG\004 (Details) AS-BUILTS.dwg

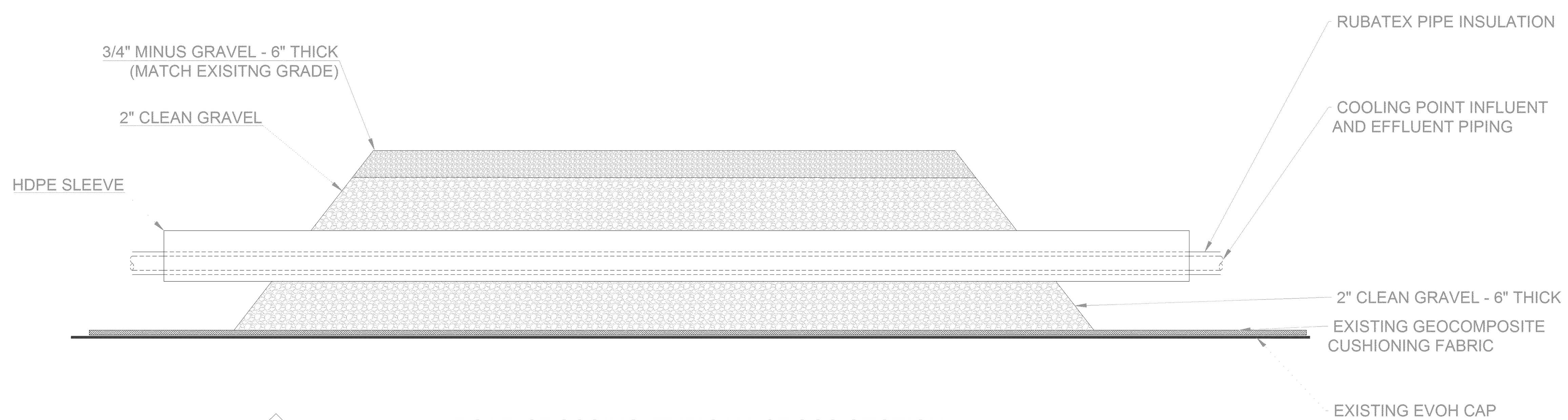
REVISION | DATE



4 003 005 TEMPERATURE MONITORING LOCATION
NTS



6 003 005 BYPASS CONTROL VALVES
NTS



5 003 005 ROAD CROSSING (TYPICAL) CROSS SECTION
NTS

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL EXPANDED HEAT EXTRACTION PILOT STUDY ADDITIONAL HEAT EXTRACTION PTS	Engineering for a Better World FEEZOR ENGINEERING, INC.	JULY 2015 DESIGNED BY: DMK APPROVED BY: ALK
HEAT EXTRACTION SYSTEM INSTALLATION - DETAILS			REVISION / DATE
PROJECT NUMBER: BT-059	FILE PATH: C:\Users\aaron\Desktop\Cad Work\Heat Extraction Expansion\BT-059-CD-005 (Details2)AS BUILTS.dwg		

DRAWING NO.:
005

DEPTH TO LIQUID MEASUREMENTS

GIW ID	DATE	DTL From TOC	Comments
GIW-08	6/5/2015	27.4	
GIW-09	6/5/2015	--	Not reading due to pressure
GIW-11	6/5/2015	32.4	
GIW-12	6/5/2015	34.9	
GIW-13	6/5/2015	30.2	

DTL = Depth to Liquid
TOC = Top of Casing

Attachment D:

Cooler Specifications

BALTIMORE AIRCOIL COMPANY

Submittal Data Form

12-2-2014

Sold To : **Republic Services Procurement, Inc.**
700 Niehoff, Suite F
Eureka, MO 63025
United States

Project: Bridgeton Landfill
Purchase Order No: 4701161
Engineer:
BAC Order # U150293512
Representative: ROGER L ECHELMEIER COMPANY

All Information is per Unit

Quantity: 1 Model FXV-0812B-36T-M CLOSED CIRCUIT COOLING TOWER

Certified Capacity: 250.00 USGPM of 30% Propylene Glycol from 108.00°F to 85.00°F at 78.00°F entering air wet bulb and 2.45 PSIG fluid pressure drop.

Fan Motor(s): One (1) 20 HP fan motor(s): Totally Enclosed, Air Over (TEAO),
1 Speed/1 Winding - Premium Efficiency (Inverter Duty), suitable for 460 volt, 3 phase,
60 hertz electrical service.. Drives are based on 0 inches ESP.

NOTE: Inverter Duty fan motors, furnished in accordance with NEMA Standard Mg.1 -- Part 31, are required for applications usin g variable frequency drives for fan motor control.

Pump(s): One (1) 5 HP pump motor: 1 Speed/1 Winding - Energy Efficient, suitable for 460 volt, 3 phase, 60 hertz.

Submittal Information		Equipment Summary
BAC Terms and Conditions of Sale		CTI Certified Thermal Performance
Mechanical Specifications		Steel Panels and Structural Members are Constructed of Galvanized Steel
Certificate of Wind and Seismic Load Capacity		Standard Fan
Submittal Drawings/Diagrams		Galvanized Steel Fan Guard
		PVC Fill & Drift Eliminators
UP-U150293512-R1	Unit Print - RH	Galvanized Steel, Full Circuit Coil
SS- U150293512-R1	Unit Support	Integral Pumps with End Make-Up, Drain and Overflow Connections
CG- U150293512-R1	Center of Gravity	Mechanical Float Valve Assembly
BA- U150293512-R1	Basin Accessories	Electric Immersion Heaters Sized to Maintain +40°F water at a 0°F Ambient with Electrical Requirements Matching Fan Motor(s)
ML- U150293512-R1	Motor Location	Copper Heater Elements
EA- U150293512-R1	External Access	Electric Immersion Heater Controls
IA- U150293512-R1	Internal Access	External Platform with Safety Gate and Ladder Located on Louver Face(s) of Unit
BAC-C50-39189-1	Controls Enclosure	Internal Walkway and Ladder
BAC-CC-C-2-V1N-A0A -1-A0A-A0A-0-1J1-1J1 -A-3-0Z-A-A-B	Controls Wiring	NEMA 3R Combined Drive(s)
BAC-12623	Temperature Sensor Only	Temperature Sensor Only

THANK YOU FOR YOUR BUSINESS!
Rigging and Installation Instructions, as well as Operating and Maintenance Instructions are available at www.baltimoreaircoil.com

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Corporate Headquarters: 7600 Dorsey Run Road, Jessup, MD 20794 – Tele: (410) 799-6200 / Fax: (410) 799-6416

BALTIMORE AIRCOIL COMPANY

Terms and Conditions of Sale

Pricing: Prices set forth in Seller's quotation shall remain firm for thirty (30) days. Within such period, the quotation shall convert into an order provided that all of the following have occurred: (1) Buyer submits either a purchase order or a copy of Seller's quotation displaying an authorized signature of Buyer within that thirty (30)-day period; (2) Buyer provides a release for fabrication; and (3) Buyer requests a shipment date that is no later than twelve (12) weeks from the date of Buyer's submission of a purchase order or signed quotation. In the event Buyer's requested shipment date is later than twelve (12) weeks beyond such submission date, Seller's price in effect twelve (12) weeks prior to such shipment date shall apply. In the event that Buyer requests for its convenience that Seller delay delivery of products subject to an order beyond the scheduled shipment date, pricing shall be subject to the same adjustment.

Payments: Terms of payment shall be net cash in thirty (30) days from date of invoice, subject to Seller's prior credit approval. If the Buyer shall fail to make any payments in accordance with the terms and conditions of sale, the Seller, in addition to its other rights and remedies but not in limitation thereof, may, at its option, without prior notice, cancel this order as to any undelivered products or defer shipments or deliveries hereunder, or under any other agreement between Buyer and Seller, except upon Seller's receipt of cash before shipment or such security as Seller considers satisfactory. Seller reserves the right to impose an interest charge (not exceeding the lawful maximum) on the balance of each invoice not paid on its due date for the period from the due date to the date of receipt of payment by Seller. In the event Buyer's failure to make timely payments to Seller results in Seller incurring additional costs, including but not limited to collection expenses and attorneys' fees, said costs shall be added to the amount due Seller from Buyer. Buyer shall have no right to any discount or retainage and shall not withhold payment as a set-off on Seller's invoice in any amount.

Taxes: Unless listed on the front (reverse) side of this document, prices do not include any federal, state or local sales, use or value-added taxes payable in connection with this order. All such taxes shall be paid by Buyer. Buyer shall indemnify Seller from and against such taxes, plus interest and penalties thereon, including, but not limited to, tax, interest and penalties resulting from a failure to collect such taxes because of Seller's reliance upon an invalid exemption certificate provided to Seller.

Allocation of Risk: Deliveries shall be considered made when the products subject to this order are loaded on the carrier. At such time, title to the goods and all risk of loss, damage or shortage shall pass to Buyer, and any claims based thereon must be filed by Buyer with the carrier.

Force Majeure: Seller shall under no circumstances be liable for any loss or damage resulting from delay or failure in the performance of its obligations under this contract to the extent that such performance is delayed or prevented by: fires, floods, war, terrorist activities, riots, strikes, freight embargoes or transportation delays, shortage of labor, inability to secure fuel, material, supplies or power at current prices, or on account of shortages thereof; acts of God or of the public enemy; any existing or future laws or acts of the federal, state or local government (including specifically, but not exclusively, any orders, rules or regulations issued by any official or agency of any such government) affecting the conduct of Seller's business with which Seller in its judgment and discretion deems it advisable to comply as a legal or patriotic duty, or to any case beyond the Seller's reasonable control.

Warranties: Seller warrants that the equipment sold under this contract shall be free from defects in material and workmanship for a period of twelve (12) months from the date of equipment startup or eighteen (18) months from the date of shipment, whichever occurs first. The following original equipment components only are warranted against defects in materials and workmanship for a period of five (5) years from date of shipment: fans, fan shafts, fan motors, bearings, sheaves, gearboxes, driveshafts, couplings, and mechanical equipment support. Details of option-specific warranties follow:

> **Replacement Parts** provided by Seller under its original equipment warranty obligations are warranted against defects in materials and workmanship for a period of twelve (12) months from date of shipment or until expiration of their original warranty, whichever occurs first. Parts purchased after expiration of the original equipment warranty are warranted against defects in materials and workmanship for a period of twelve (12) months from date of shipment.

Written notice of any defect shall be given to Seller immediately upon discovery by Buyer, and shall fully describe the claimed defect. Defective parts shall be repaired or replaced F.O.B. point of shipment, provided that inspection by Seller verifies the claimed defect(s). This shall be Buyer's exclusive remedy. **This warranty does not cover the costs of removing, shipping or reinstalling the equipment. Repairs made without the prior written approval of Seller shall void all warranties covering material and workmanship.** Any descriptions of the product(s) in the contract are for the sole purpose of identification and do not constitute a warranty. In the interest of product improvement, Seller reserves the right to change specifications and product design without incurring any liability therefore. The foregoing express warranties or those set forth elsewhere on this document are the only warranties of Seller applicable to the product(s) sold under this contract. **All other warranties, whether verbal or written, and all warranties implied by law, including any warranties of merchantability or fitness for a particular purpose, are hereby excluded. Failure on the part of Buyer or of other parties to properly maintain the product(s) sold under this contract, or the operation of such product(s), by Buyer and/or other parties under conditions more severe than those for which such product(s) were designed, shall void all warranties covering materials and workmanship. Seller's warranties do not apply to defects in product(s) for which payment in full has not been received by Seller, and said warranties do not cover normal wear and tear or the erosion, corrosion and/or deterioration of the product(s) from unusual causes. No warranties by Seller shall apply to accessories manufactured by others,** inasmuch as they are warranted separately by their respective manufacturers, except as stated above. Buyer assumes liability for and shall bear the costs of compliance with all laws, regulations, codes standards or ordinances applicable to the location, operation and maintenance of the product(s) sold under this contract, including those requirements pertaining to the distances between such product(s) and air-conditioning system duct intakes. No representative or agent of Seller is authorized to enlarge upon the express warranties of Seller.

Cancellation/Changes/Returns: Cancellation of or changes in any order by Buyer shall not be effective without Buyer's notice thereof received, agreed to, and confirmed in writing by Seller. If Seller, in its absolute discretion, approves Buyer's cancellation of an order, Buyer agrees to pay a reasonable cancellation charge. Seller's prior written consent must be obtained before Buyer returns any products, and when so returned will be subject to a handling charge and transportation costs payable by Buyer.

Corporate Headquarters: 7600 Dorsey Run Road, Jessup, MD 20794 – Tele: (410) 799-6200 / Fax: (410) 799-6416

Liability/Indemnification: Seller shall not be liable for any damages caused by delay in delivery of the products. Buyer shall hold harmless and indemnify Seller from and against all liability, claims, losses, damages, and expenses (including attorneys' fees) for personal injury and property damage arising out of Buyer's improper unloading, handling, or use of the products subject to this order, and for Buyer's infringement of another's property rights. The Seller's maximum liability from any causes whatsoever, whether in breach of contract, tort (including negligence), strict liability, or otherwise, shall not exceed the contract price. Neither Buyer nor Seller shall in any event be liable to the other, whether such liability arises out of breach of contract, tort (including negligence), strict liability or any other cause or form of action, for any consequential, special, indirect or incidental damages, including but not limited to loss of actual or anticipated profits or loss of use arising out of this contract, other than such damages resulting from the willful misconduct of Buyer or Seller.

Storage: In the event that Buyer is unable to accept delivery of goods and the Seller is required to hold goods beyond two (2) working days from fabrication completion, a storage fee equal to the greater of $200/day or 0.20% of the total order value/day will be assessed by Seller for every day beyond two (2) working days from fabrication date which it is required to store goods on behalf of Buyer. Storage will be assessed monthly and will need to be paid in full prior to a new shipment date being scheduled.

Government Contracts: If Buyer's purchase order is for products to be used in the performance of a U.S. Government contract, those clauses of applicable procurement regulations mandatorily required by federal law to be included in U.S. Government subcontracts shall be incorporated herein by reference.

Export Transactions: Buyer shall comply with all applicable export laws and regulations of the U.S. Government, and shall hold harmless and indemnify Seller from and against all liability, damages, and expenses (including attorneys' fees) incurred by Seller as a result of Buyer's violation of any U.S. Government export and/or international antiboycott laws or regulations.. Buyer certifies that it will be the recipient of the products to be delivered by seller. Buyer acknowledges that products are subject to export/import control laws of various countries, including the Export Administration Regulations of the United States. Products sold by seller cannot be transferred, sold or re-exported to any party on the Entity List or Restricted Persons list of the US Department of Commerce Bureau of Industry and Security, any party designated by the US Treasury Department Office of Foreign Asset Control and any party debarred or sanctioned for proliferation or terrorism reasons by the US State Department.

Agreement of Sale: Buyer's order is accepted on the terms and conditions stated herein and Seller's acceptance of Buyer's order is expressly made conditional upon Buyer's assent to such terms and conditions, including any of Seller's terms and conditions which may be additional to or different from those contained in Buyer's purchase order or otherwise. Such assent shall be deemed to have been given unless written notice of objection to any such terms and conditions (including inconsistencies between Buyer's purchase order and this acceptance) is given by Buyer to Seller promptly upon receipt of this acknowledgment. Any agreement or understanding, oral or written, which modifies or waives the terms and conditions herein (whether contained in Buyer's purchase order or other documentation) shall be deemed material and shall be rejected unless hereafter agreed to in writing and signed by Seller's authorized officer. Waiver by Seller of any breach or default hereunder shall not be deemed a waiver by Seller of any other or subsequent breach or default which may thereafter occur. Neither the rights nor the obligations of either Buyer or Seller are assignable without the prior written consent of the other party. This agreement of sale and all rights and obligations of Buyer and Seller shall be governed by and construed in accordance with the laws of the State of Maryland.

Electronic copy of the latest version is available online at http://baltimoreaircoil.com/english/terms. (Revised – **06/26/2014**)

BALTIMORE AIRCOIL COMPANY

Mechanical Specifications

12-2-2014

Customer: Republic Services Procurement, Inc.
Project: Bridgeton Landfill
Purchase Order No: 4701161
Engineer:
BAC Order # U150293512

All Information is per Unit

Quantity: 1 Model FXV-0812B-36T-M CLOSED CIRCUIT COOLING TOWER

CTI Certification:

The thermal performance is certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201.

Materials of Construction:

All structural steel components are constructed from G-235 (Z700 metric) hot-dip galvanized steel. The edges of the hot-dip galvanized steel components are given a protective coat of zinc-rich compound. The basin includes a depressed section with drain/clean-out connection and the areas under the fill sections are sloped toward the depressed section for easy cleaning.
The casing is constructed entirely from heavy gauge, G-235 (Z700 metric) hot-dip galvanized steel panels. Hinged access doors are provided on each side wall of the tower for access to the eliminators and the fan plenum section for all cells. The doors are made of a steel frame matching the unit construction.
The air inlet louvers are constructed of PVC honeycomb shape louver which also act as an air inlet screen and block sunlight to the basin and the front of the fill.

Fan Type:

The unit is provided with the standard fan to maximize the capacity. The fan is driven by the BALTIDRIVE Power Train. This drive system consists of cast aluminum sheaves located on minimum shaft centerline distances. A premium efficient fan motor provides maximum performance and is backed by BAC's comprehensive 5-year motor and fan drive warranty.

Fan Guard(s):

A heavy gauge, G-235 (Z700 metric) hot-dip galvanized steel wire fan guard is provided over each fan cylinder.

Fill:

The BACross® Fill and integral drift eliminators are formed from self-extinguishing (per ASTM D-568) polyvinyl chloride (PVC), having a flame spread rating of 5 per ASTM Standard E84-77a, and are impervious to rot, decay, and fungus or biological attack. The fill is elevated above the cold water basin floor to facilitate cleaning. This fill is suitable for a maximum entering water temperature of 130°F (54.44°C). The eliminators are designed to effectively strip entrained moisture from the leaving airstream with a minimum of air resistance.

Coil Type:

The coil is suitable for cooling fluids compatible with carbon steel in a closed system. The coil(s) will be constructed with continuous 1.05" O.D. all prime surface steel tubes continuously formed and bent in a serpentine shape, encased in steel framework. The entire assembly is hot-dip galvanized after fabrication. Tubes will be sloped for liquid drainage. Coil has a maximum allowable working pressure of 300 psig (2170 kPa) and is tested at 375 psig (2685 kPa) air pressure under water. The system should have a vent placed at the highest point in the installation to facilitate filling and drainage (provided and installed by others).

Spray Water Pump Assembly:

Each cold water basin has an integral pump with large area, lift out, steel strainer screens including perforated openings sized smaller than the water distribution nozzle orifices. Strainers include anti-vortexing baffles to prevent air entrainment.. A close-coupled, bronze-fitted pump with a mechanical seal is mounted on the basin. The pump motors are premium efficient, totally enclosed, fan cooled (TEFC). A water bleed line with a metering valve to control the bleed rate is installed between the pump discharge and the overflow connection. Electrical requirements match the fan motor.

WLLFOIA4312 - 001 - 0018036

Basin Water Level Control:

The unit is supplied with a make-up valve with unsinkable polystyrene filled plastic float arranged for easy adjustment. The corrosion resistant make-up valve is suitable for water supply pressures between 15 psig (103 kPa) and 50 psig (345 kPa).

Basin Heater(s):

A minimum number of high-watt-density electric immersion heater elements, sized to maintain +40°F (+4°C) basin water at 0°F (-18°C) ambient with a 10 mph (16 km/h) wind speed, is provided. Electrical requirements match fan motor. Wiring is not included.

Heater Element Material of Construction:

The unit is supplied with copper heater elements.

Basin Heater Control:

An electric immersion heater control package, including thermostat(s) and low water cutout switch(es) or probe(s), is provided. Disconnect switch, contactor, and wiring are not included.

External Platform at Louver Face:

The unit will be configured with a platform (with FRP grating) with galvanized steel supports, an aluminum ladder and safety railing on the louver face. The safety rails will be constructed of 1 1/4" (32 mm) galvanized steel pipe. A spring loaded safety gate is provided. These access options meet OSHA standards. These components ship loose and are to be assembled and are installed in the field by others.

Internal Access Option:

The unit has access doors on both ends, an internal walkway, and an internal aluminum ladder with galvanized steel supports to facilitate access to the mechanical equipment. All components meet pertinent OSHA standards.

Controls:

Qty Per Order	BAC Control Package Selection
1	BAC Control Package System Voltage: 460 System Frequency: 60

Enclosed Control

Enclosure: NEMA 3R
Disconnect Type: Circuit Breaker
Control Voltage: 120

Qty	Item
1	Enclosed Control for (1) VFD 20 HP Main Fan Motor, (1) 5 HP Spray Pump Motor, (1) 8 kW Basin Heater; Includes Temperature Sensor with Transmitter and Thermowell Catalog Number: BAC-CC-C-2-V1N-A0A-1-A0A-A0A-0-1J1-1J1-A-3-0Z-A-A-B Enclosure Drawing: BAC-C50-39189-1 Wiring Diagram: BAC-CC-C-2-V1N-A0A-1-A0A-A0A-0-1J1-1J1-A-3-0Z-A-A-B

BALTIMORE
AIRCOIL COMPANY

Certificate of Wind and Seismic Load Capacity
2006 and 2009 International Building Codes (IBC)

Customer:	**Republic Services Procurement, Inc**
Project:	**Bridgeton Landfill**
Purchase Order No:	**4701161**
Engineer:	
BAC Order #:	**U150296303**

Product Line:	FXV Closed Circuit Cooling Tower
Model Number:	FXV-0812B-36T-M

The Baltimore Aircoil Company evaporative cooling product referenced in this certificate has been designed, analyzed, and tested in accordance with the wind and seismic load requirements of the 2006 IBC, 2009 IBC, and ASCE/SEI 7-05. Seismic qualification is based on analysis and full-scale, tri-axial, shake-table testing conducted in accordance with ICC-ES Acceptance Criteria AC156 (2007), "Acceptance Criteria for Seismic Qualification By Shake-Table Testing of Nonstructural Components and Systems."

Wind and seismic load capacities for the referenced unit are provided below. It is the responsibility of the purchaser to determine the suitability of this unit for the specific application and to design the anchorage and support system for the project wind and seismic loads. Field modifications to the unit may void this certificate.

Wind Load Rating		
Design Wind Pressure (psf):	p = 35.00	
Installation Restrictions:	None	
Seismic Load Rating		
Design Spectral Acceleration (g) for Importance Factor, I_p = 1.0:	S_{DS} = 4.20	on grade (z/h = 0.0), rigid mount
	S_{DS} = 1.40	on rooftop (z/h = 1.0), rigid mount
	S_{DS} = 0.94	on rooftop (z/h = 1.0), flexible mount
Design Spectral Acceleration (g) for Importance Factor, I_p = 1.5:	S_{DS} = 1.5	on grade (z/h = 0.0), rigid mount
	S_{DS} = 2.4	on rooftop (z/h = 1.0), rigid mount
Installation Restrictions:	Outdoor	

Corporate Headquarters: P.O. Box 7322, Baltimore, MD 21227 - Tele: (410) 799-6200 / Fax: (410) 799-6416

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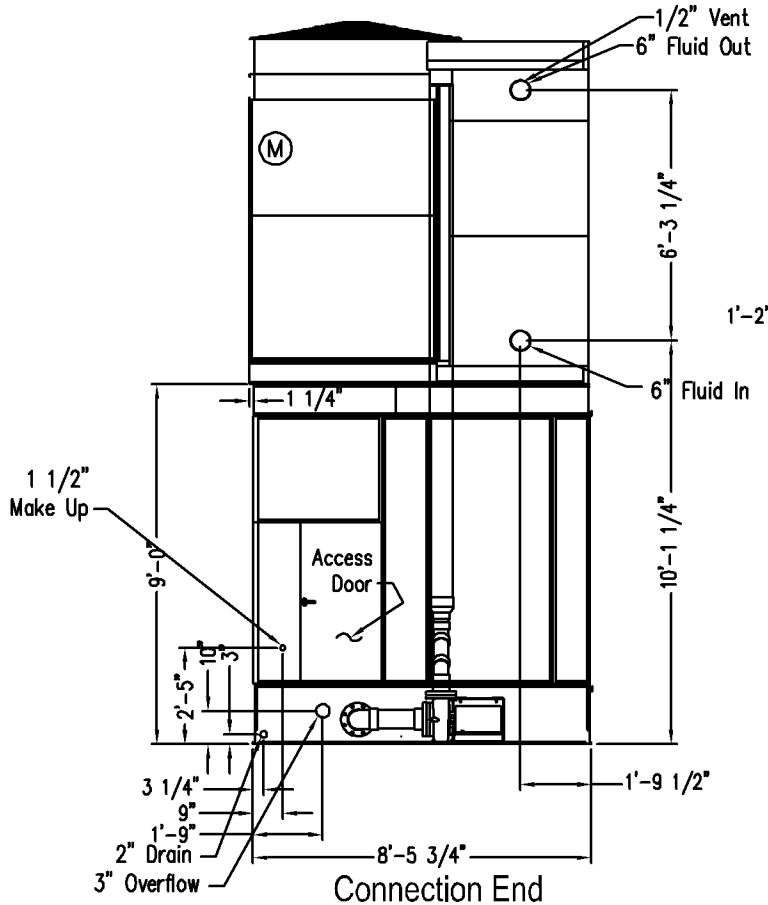
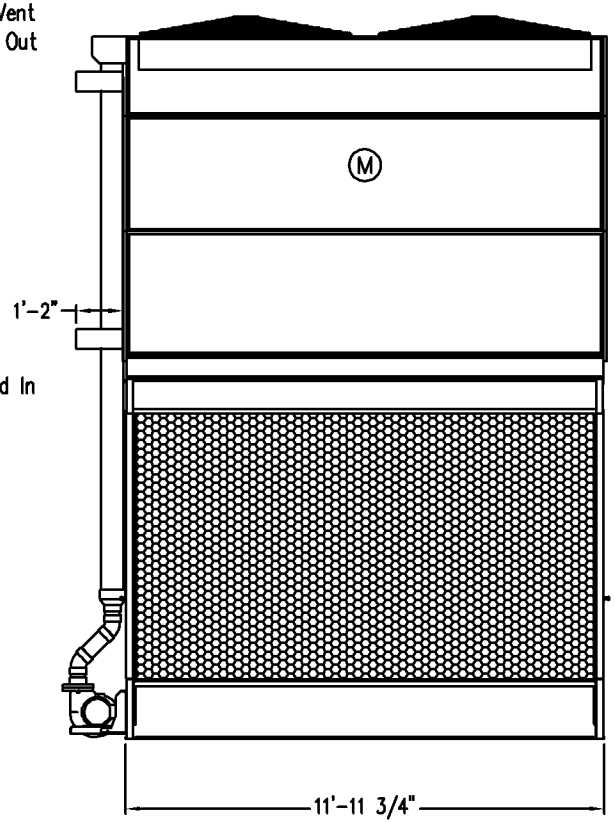
Data Version 1.07
DWG Version 1.3

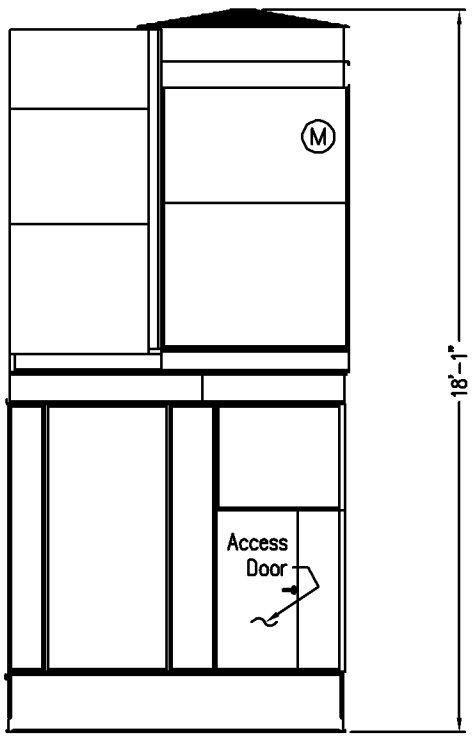
Notes
1) All dimensions are in feet and inches. Weights are in pounds.
2) Dimensions showing location of coil and spray water connections are approximate and should not be used for prefabrication of connecting piping.
3) The area above the discharge of the fan must be unobstructed.
4) For weight loading and support requirements refer to the suggested steel support drawing.
5) Do not support piping from unit connections. All necessary piping supports to be supplied by others.
6) Weights include all the options and accessories.
7) All unit piping conections 3" and smaller are MPT unless otherwise noted.
8) Coil is provided with a 1/2" threaded vent located on the upper outlet pipe stub.
9) All Coil conections are beveled for weld unless otherwise noted.



Connection End



Air Inlet Side



Model Number	Shipping Weight	Operating Weight	Heaviest Section
FXV-0812B-36T-M	13236	20454	9372

Right Hand

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

8.5 X 12 Unit Print

DRAWING NUMBER:
UP-U150293512-R1

WLLFOIA4312 - 001 - 0018039

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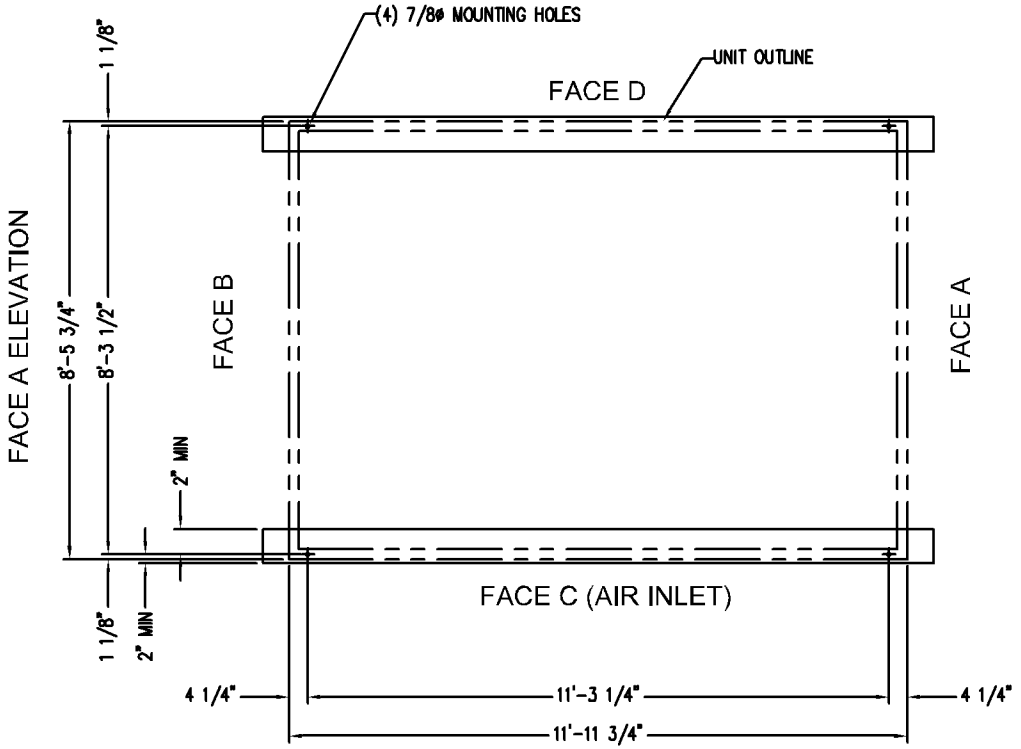
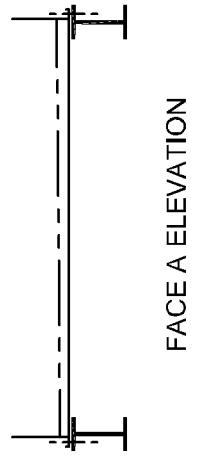
Data Version 1.07
DWG Version 1.01

Notes
1) Supporting steelwork and anchor bolts to be designed and furnished by others.
2) All supporting steel must be level at top.
3) Beams should be selected in accordance with accepted structural practice, maximum deflection of beam under unit to be 1/360 of span, not to exceed 1/2 inch.
4) Supporting steel will be greater than or equal to the length of the basin.
5) Alternatively the unit may be supported on columns at the four corners of the unit. Consult your BAC Representative for details.
6) If vibration isolation rails are used between unit and supporting steel, be certain to allow for the length of the vibration rails when determining length of supporting steel. Vibration rail length and mounting hole locations may differ from those of the unit. Refer to vibration isolator drawings for this data.
7) Each beam should be designed, as a minimum, for 65% of the total unit operating weight applied as a uniformly distributed load.
8) Do not use this drawing to size point vibration isolators. See your BAC Representative for details.
9) All Dimensions are in feet and inches. All weights are in pounds.
10) Weights include all of the options and accessories.



PLAN VIEW



PLAN "A" STEEL

Model Number	Shipping Weight	Operating Weight
FXV-0812B-36T-M	13236	20454

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

Single Cell Unit Support

DRAWING NUMBER:
SS-U150293512-R1

WLLFOIA4312 - 001 - 0018040

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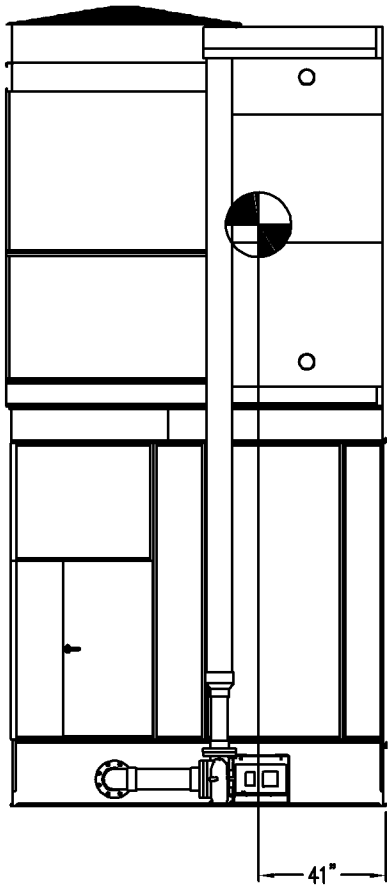
Data Version 1.07
DWG Version 1.0

Notes
1) All Dimensions are in feet and inches. All weights are in pounds.
2) Center of gravity location is based on operating weight.



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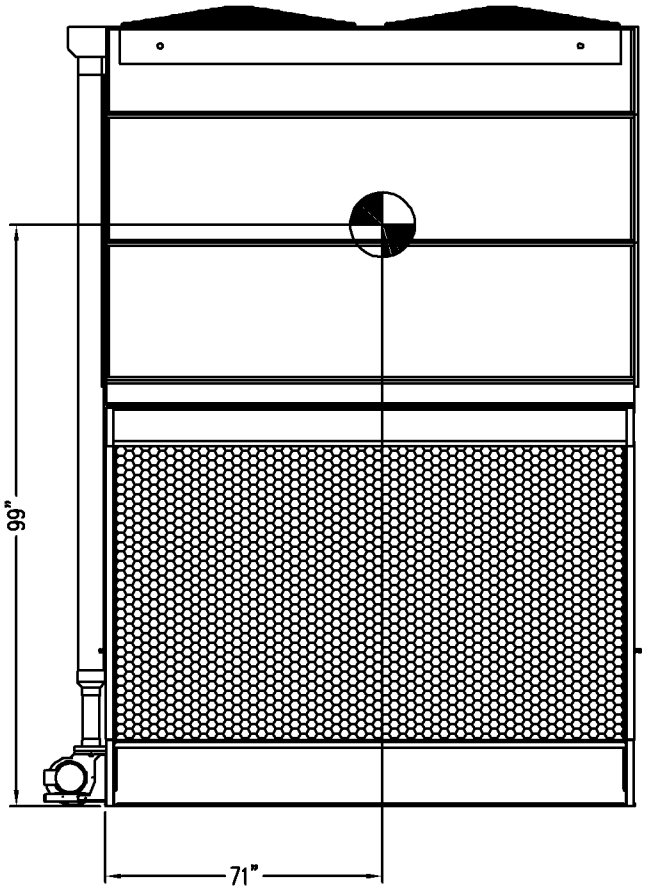
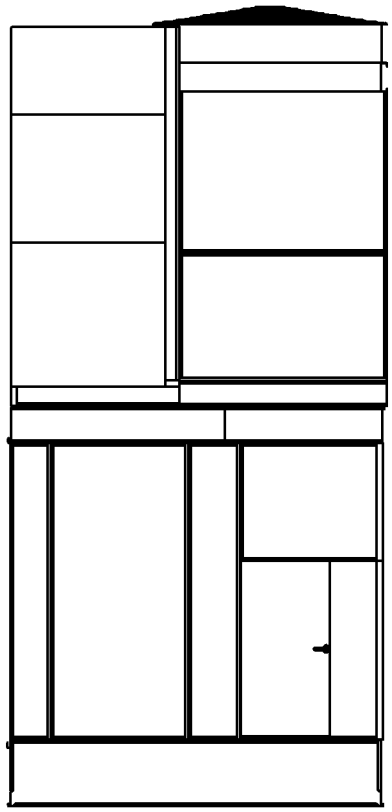


Air Inlet Side



Model Number	Shipping Weight	Operating Weight	Heaviest Section
FXV-0812B-36T-M	13236	20454	9372

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

8.5 X 12 Unit Center of Gravity

DRAWING NUMBER:
CG-U150293512-R1

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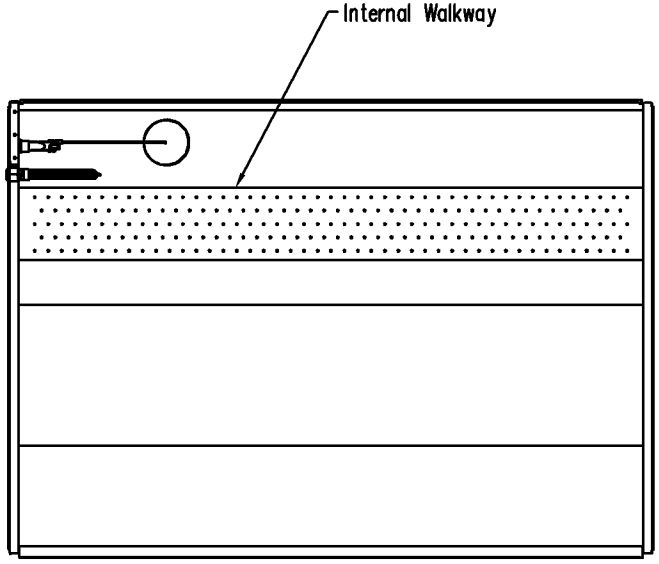
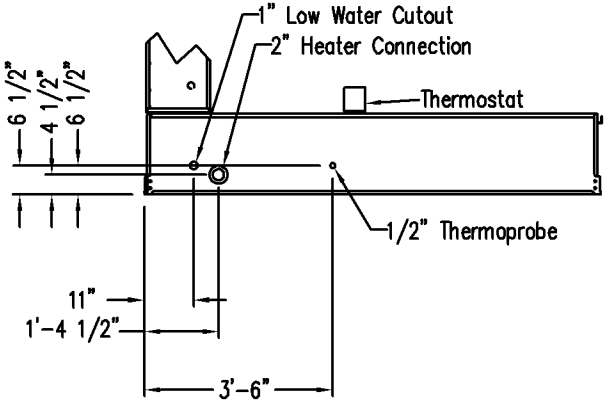
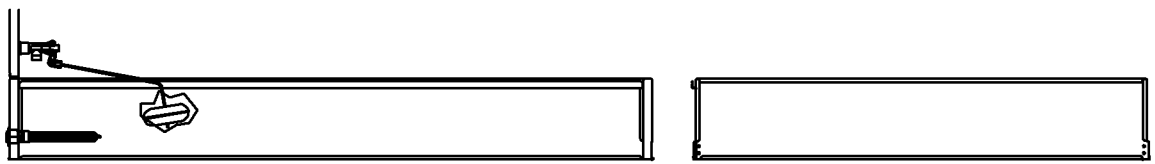
Data Version 0.00
DWG Version 1.0



Air Inlet





Air Inlet End

AMBIENT TEMPERATURE: 0 DEGREES F
POWER (EACH): 8 KW
VOLTAGE: 460V
PHASE: 3
FREQUENCY: 60HZ

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

8.5 X 12 Basin Accessories

DRAWING NUMBER:
BA-U150293512-R1

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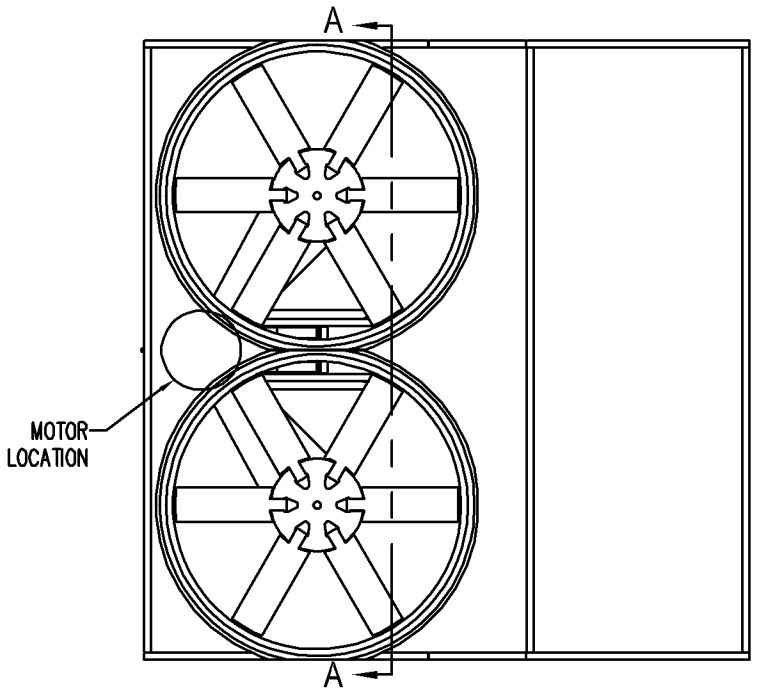
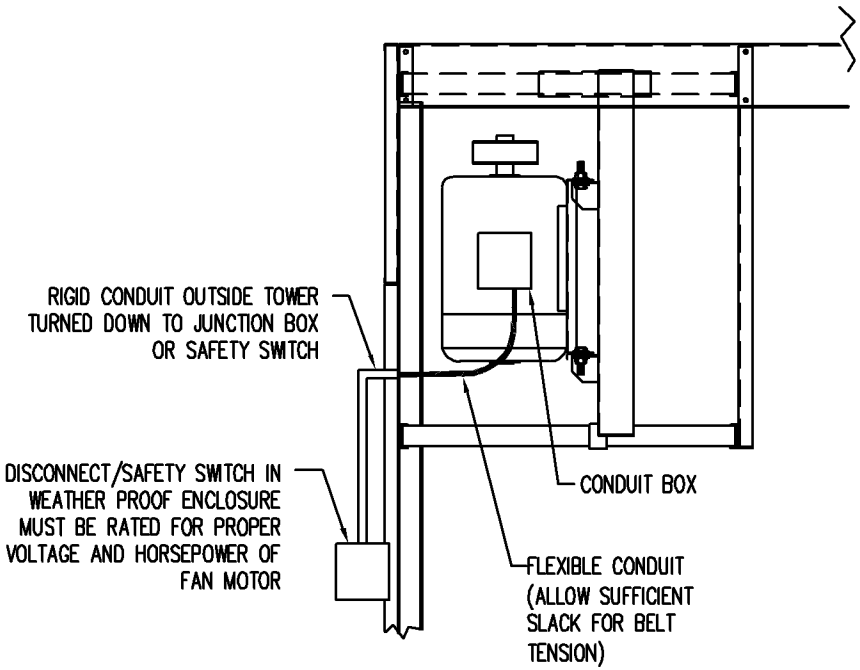
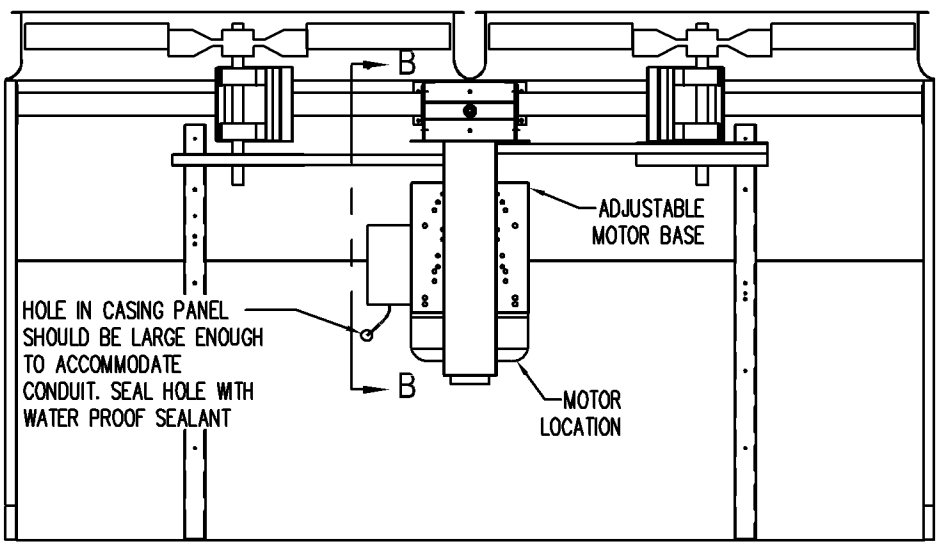
Data Version 0.00
DWG Version 1.0



PLAN VIEW



SECTION B-B



SECTION A-A

Notes

1) All conduit must be water tight and pitched downward to allow condensation to drain away from motor conduit box, therefore, do not run the conduit through the fan deck.
2) All wiring must conform to local and national electrical codes. Junction box/safety switch and all conduit from fan motor conduit box to be sized, provided and installed by others.
3) Rigid conduit outside casing panel must turn down to junction box.
4) On multi-cell units, use seprate conduit lines for each fan motor. Run conduit through adjacent cell to junction box and/or disconnect switch.

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

Motor and Conduit Location
Dual Fan Standard Fan System

DRAWING NUMBER:
ML-U150293512-R1

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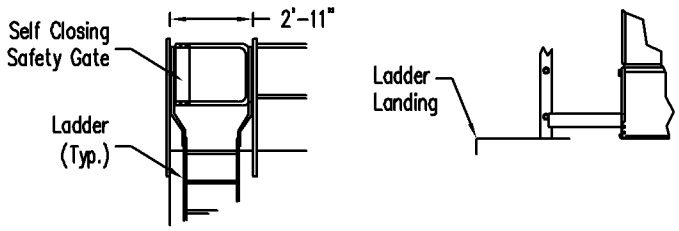
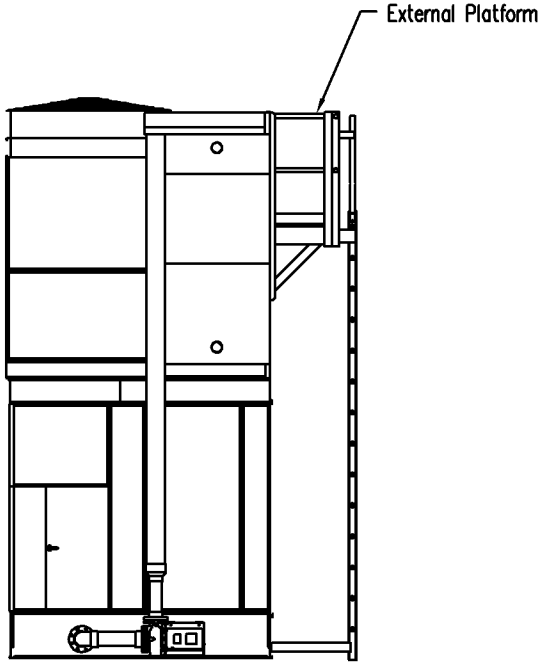
Data Version 0.00
DWG Version 1.0

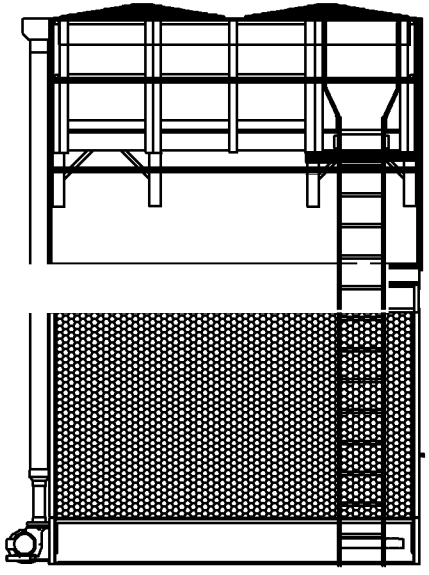
Notes
1) All Dimensions are in feet and inches. All weights are in pounds.
2) This drawing is not indicative of the specific configuration of the unit. Please refer to the unit print and other supporting drawings for configuration details.
3) External service platform and ladder ship loose for field assembly.
4) External unit access accessories ship loose for field assembly.
5) Field piping must be kept clear and supported independently of all unit access accessories.
6) Self closing, OSHA-compliant, safety gates are provided for all platform packages. Refer to OSHA and local occupational safety regulations to determine if safety gates are required.
7) Optional ladder extensions are available for all ladder packages.



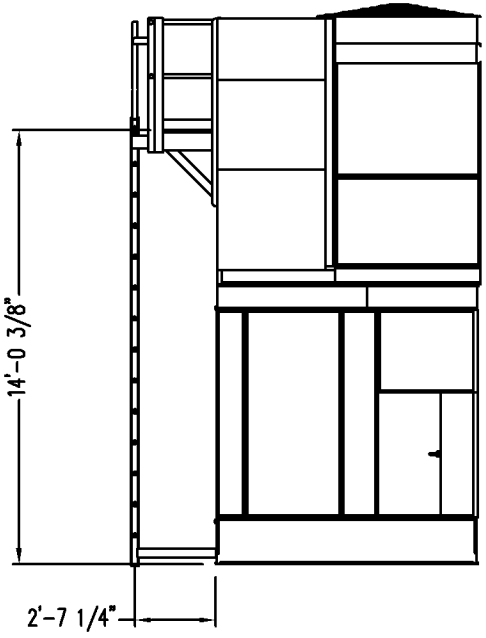
Safety Gate Detail



Connection End



Air Inlet Side



Model Number	Shipping Weight	Operating Weight	Heaviest Section
FXV-0812B-36T-M	13236	20454	9372

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

8.5 X 12 Accessories

DRAWING NUMBER:
EA-U150293512-R1

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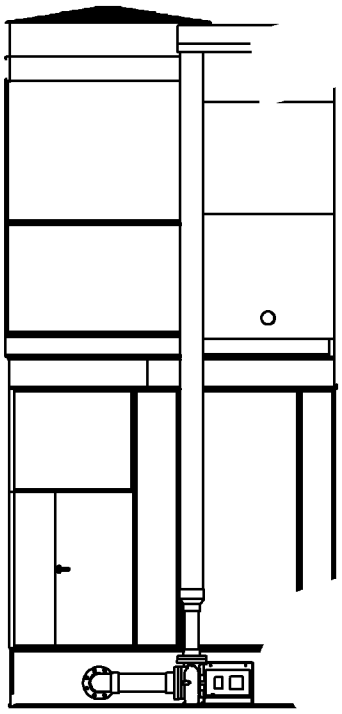
Data Version 0.00
DWG Version 1.0

Notes
1) All Dimensions are in feet and inches. All weights are in pounds.
2) This drawing is not indicative of the specific configuration of the unit. Please refer to the unit print and other supporting drawings for configuration details.
3) Internal Ladder ships loose for field assembly



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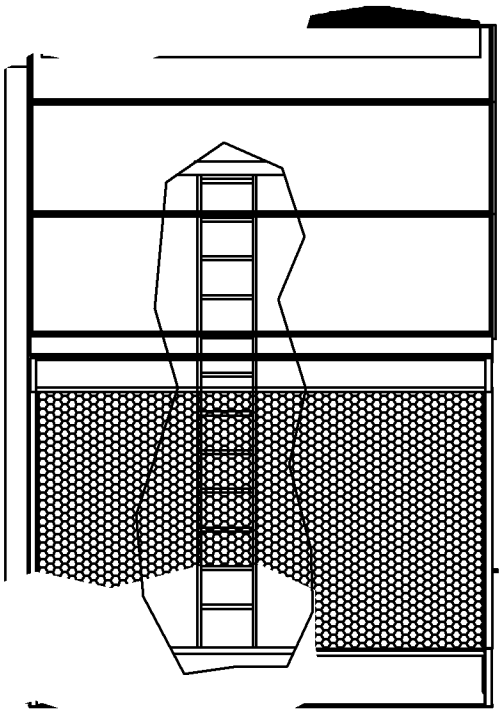
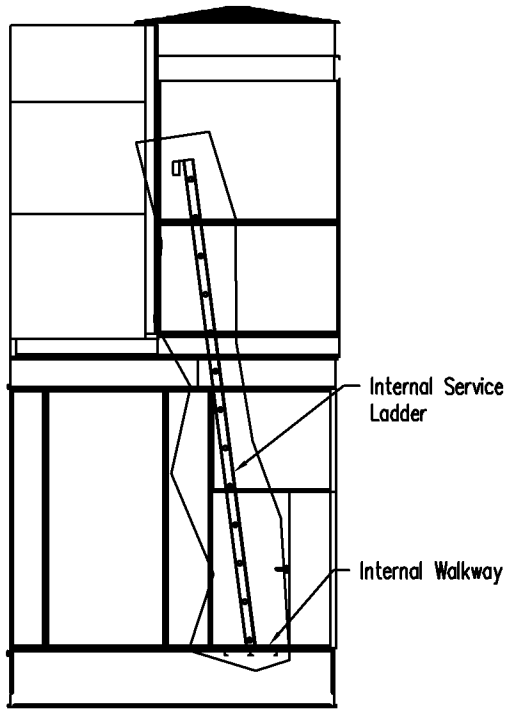


Air Inlet Side



Model Number	Shipping Weight	Operating Weight	Heaviest Section
FXV-0812B-36T-M	13236	20454	9372

ORDER NO: **U150293512**

DATE: **12/2/2014**

BALTIMORE AIRCOIL COMPANY

8.5 X 12 Internal Access

DRAWING NUMBER:
IA-U150293512-R1

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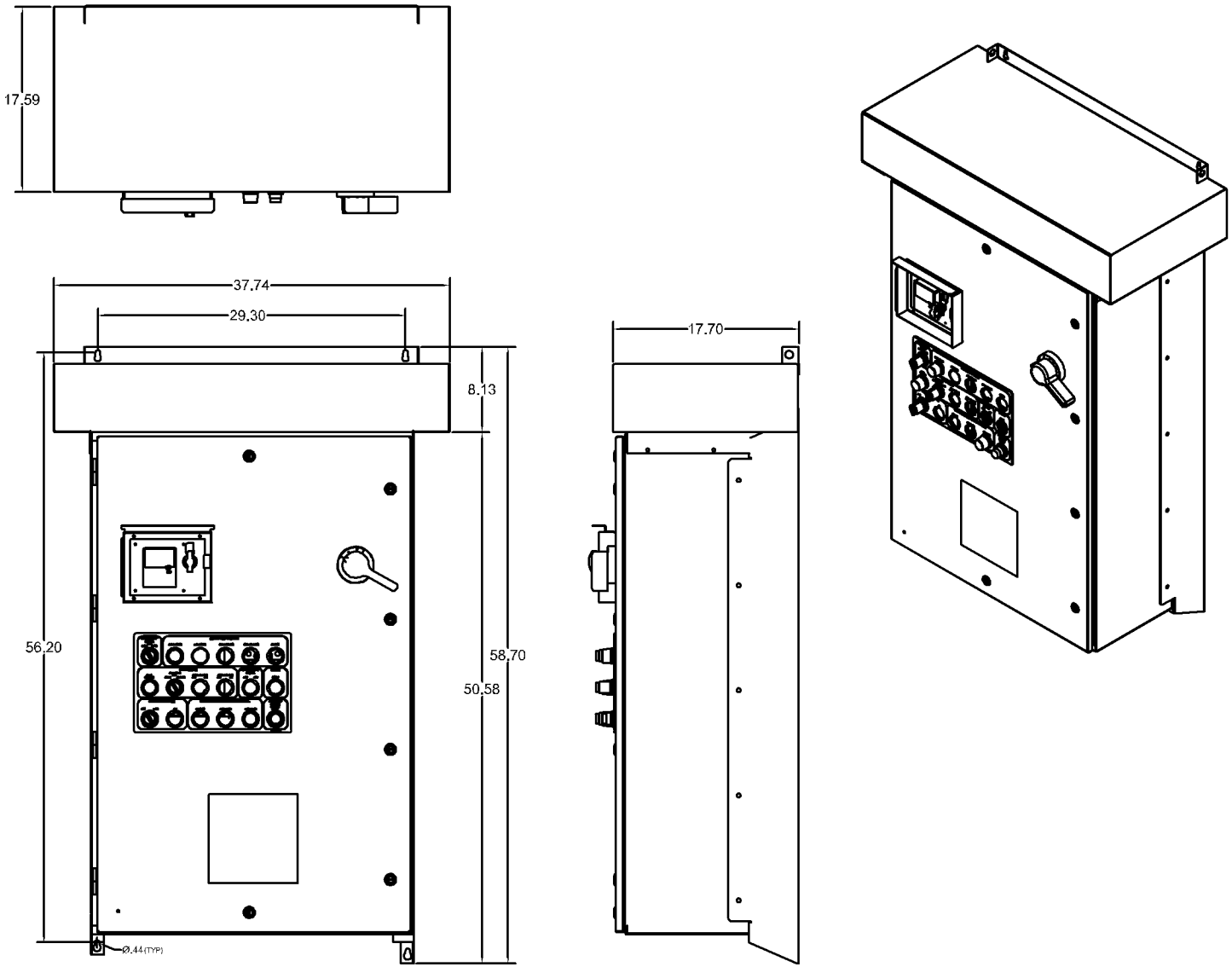

Ref: 84-32612

MOTOR CONTROLS ORDER NO: U150293512 DATE: 12/2/2014	Baltimore Aircoil	DIMENSIONAL FOR EATON COMMON BOX NEMA 3R MILD AND 304 SST STEEL DRAWING NUMBER: BAC-C50-39189-1 REV 1

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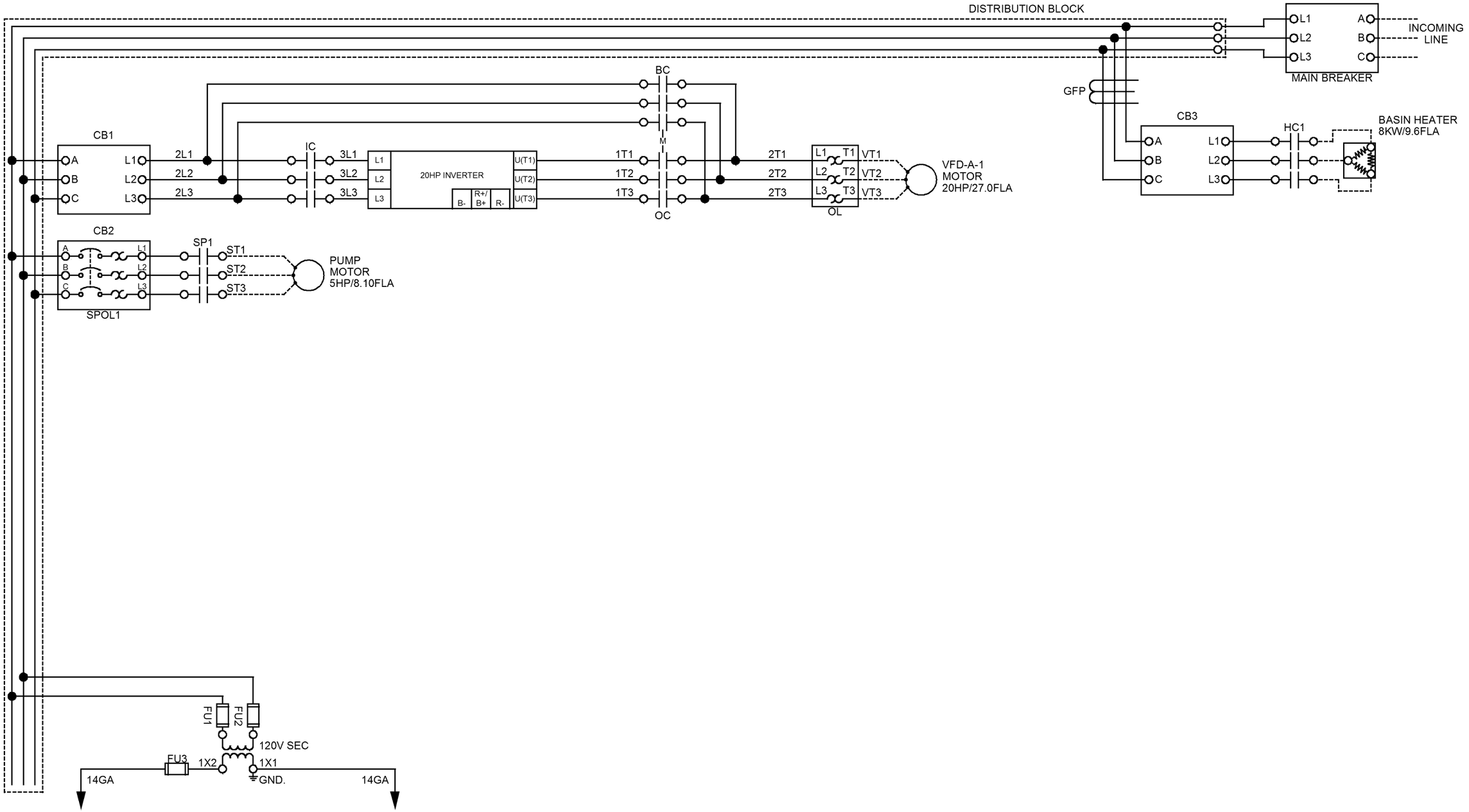
VOLTAGE 460V 60HZ



COOLING TOWER CONTROLS	BALTIMORE AIRCOIL COMPANY	FOR SUBMITTAL PURPOSES ONLY	
ORDER NO: U1502935-012 Page 1 of 6		DRAWING NUMBER: BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B	REV 1
DATE: 12/02/2014			

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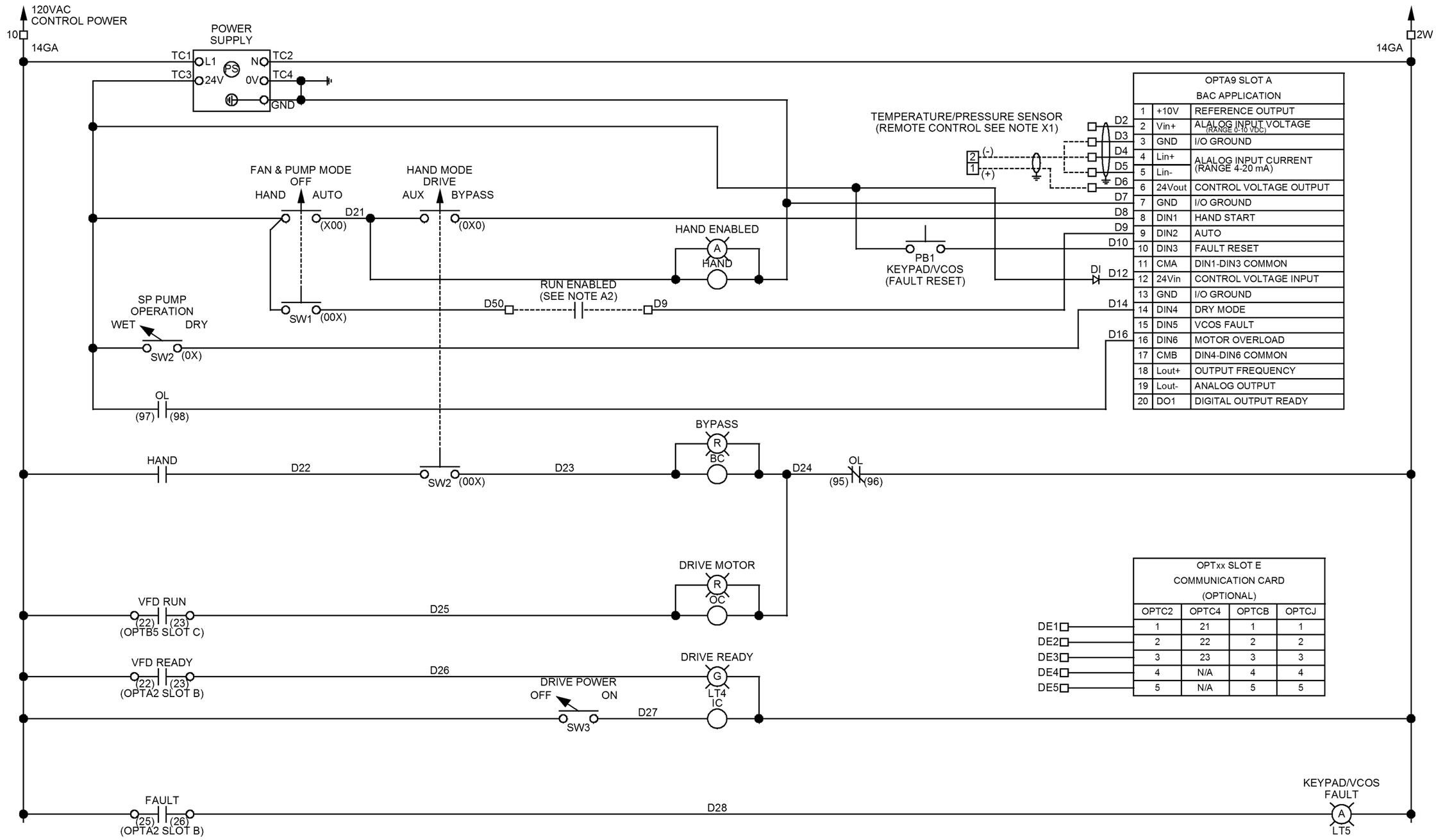

COOLING TOWER CONTROLS

ORDER NO: U1502935-012 Page 2 of 6

DATE: 12/02/2014

BALTIMORE AIRCOIL COMPANY

FOR SUBMITTAL PURPOSES ONLY

DRAWING NUMBER: BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B

REV 1

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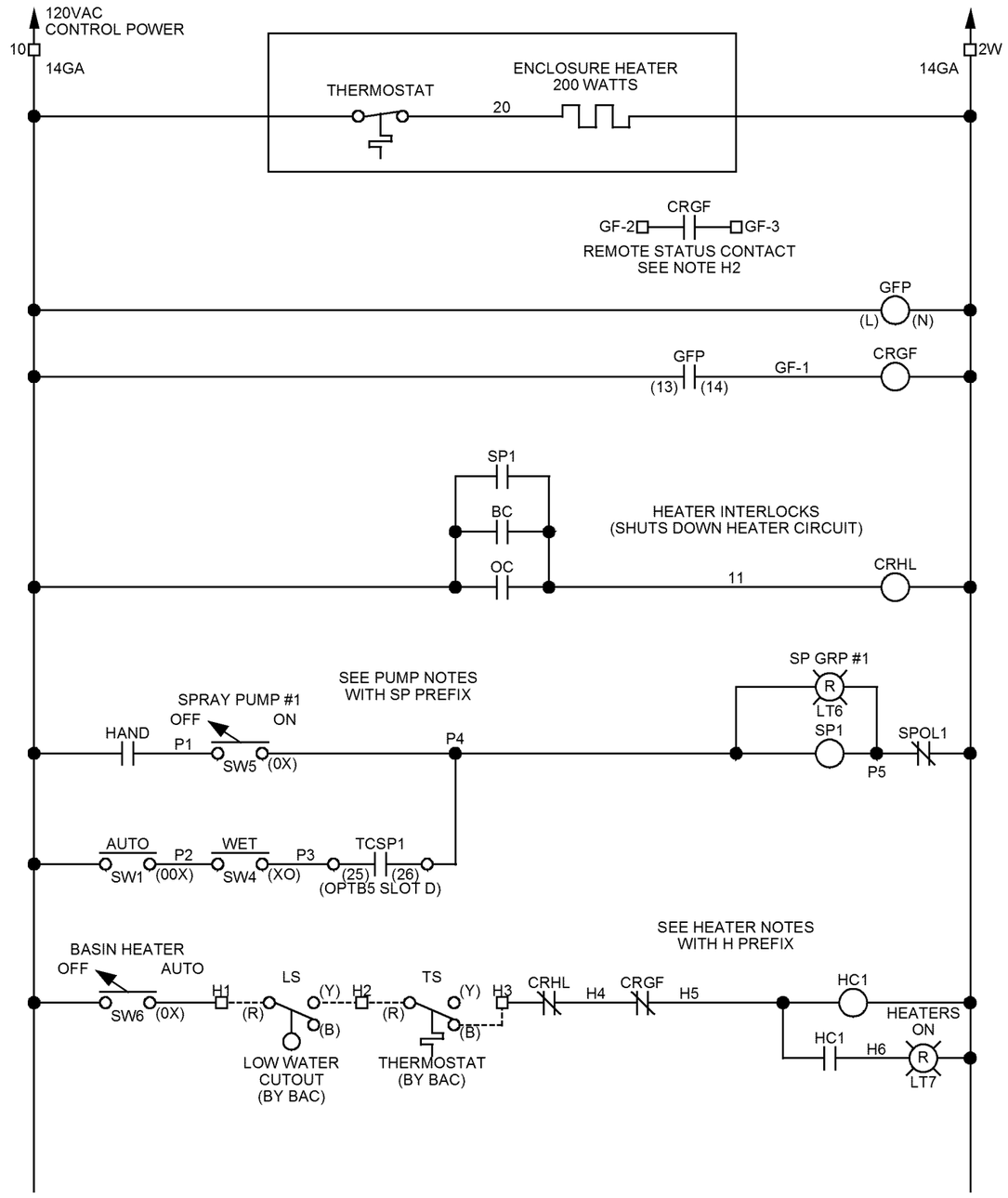

COOLING TOWER CONTROLS

ORDER NO: U1502935-012 Page 3 of 6

DATE: 12/02/2014

BALTIMORE AIRCOIL COMPANY

FOR SUBMITTAL PURPOSES ONLY

DRAWING NUMBER: **BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B**

REV **1**

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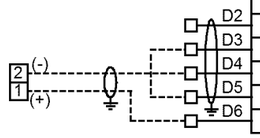
GENERAL NOTES: ALL CUSTOMER INSTALLED DEVICES (SHOWN WITH DASHED LINES) TO BE UL LISTED DEVICES AND MUST COMPLY WITH APPLICABLE CODES AND ORDINANCES

DANGER - POTENTIAL HIGH VOLTAGE HAZARD

(X1) USE ONLY TWISTED SHIELDED CABLE FOR ALL ANALOG SIGNAL WIRING. FOR REMOTE CONTROL APPLICATIONS REMOVE THE JUMPER BETWEEN 3 AND 5 WIRE POSITIVE INTO 4 AND NEGATIVE INTO 5 FOR 4-20MA APPLICATIONS OR WIRE POSITIVE INTO 2 AND NEGATIVE INTO 3 FOR 0-10VDC.
FOR SPECIFIC WIRING INSTRUCTIONS SEE ADDITIONAL X1 NOTES.

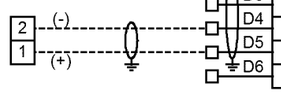
FOR ADDITIONAL CUSTOMER INPUT WIRING INSTRUCTIONS PLEASE SEE THE DIFFERENT APPLICATIONS BELOW

(X1) FOR 4-20mA TEMPERATURE/PRESSURE SENSOR APPLICATIONS
USE CONTROL MODES 0-6



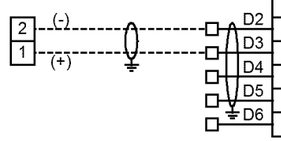
OPTA9 SLOT A BAC APPLICATION		
1	+10V	REFERENCE OUTPUT
2	Vin+	ALALOG INPUT VOLTAGE (RANGE 0-10 VDC)
3	GND	I/O GROUND
4	Lin+	ALALOG INPUT CURRENT (RANGE 4-20 mA)
5	Lin-	
6	24Vout	CONTROL VOLTAGE OUTPUT

(X1) FOR 4-20mA CDE REMOTE CONTROL APPLICATIONS
USE CDERMTCNTRL MODE 8



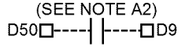
OPTA9 SLOT A BAC APPLICATION		
1	+10V	REFERENCE OUTPUT
2	Vin+	ALALOG INPUT VOLTAGE (RANGE 0-10 VDC)
3	GND	I/O GROUND
4	Lin+	ALALOG INPUT CURRENT (RANGE 4-20 mA)
5	Lin-	
6	24Vout	CONTROL VOLTAGE OUTPUT

(X1) FOR 0-10V CDE REMOTE CONTROL APPLICATIONS
USE CDERMTCNTRL MODE 8



OPTA9 SLOT A BAC APPLICATION		
1	+10V	REFERENCE OUTPUT
2	Vin+	ALALOG INPUT VOLTAGE (RANGE 0-10 VDC)
3	GND	I/O GROUND
4	Lin+	ALALOG INPUT CURRENT (RANGE 4-20 mA)
5	Lin-	
6	24Vout	CONTROL VOLTAGE OUTPUT

(A2) REMOTE START INPUT USED FOR ALL APPLICATIONS LISTED ABOVE



(H1) IMMERSION HEATERS SHOULD BE INTERLOCKED WITH CIRCULATING PUMP TO DE-ENERGIZE HEATERS WHEN PUMP IS RUNNING.

(H2) A RELAY CONTACT IS PROVIDED FOR REMOTE MONITORING GROUND FAULT STATUS OF BASIN HEATERS. A GROUND FAULT CONDITION WILL DE-ENERGIZE ALL BASIN HEATERS. OPERATOR IS RESPONSIBLE FOR RESETTING THE GROUND FAULT RELAY AFTER ESTABLISHING THAT THE GROUND FAULT HAS BEEN CLEARED. FAILURE TO CLEAR THE GROUND FAULT WILL PREVENT THE BASIN HEATERS FROM PROTECTING THE BASIN WATER FROM FREEZING WHEN THE UNIT IS IDLE.

(SP1) A THERMOSTAT INSTALLED IN THE UNIT'S COIL OUTLET PIPING MAY BE USED TO PROVIDE THE SPRAY PUMP START SYSTEM INPUT. THE THERMOSTAT IS TYPICALLY SET AT 5°F BELOW THE FAN OR FAN DAMPER SET POINT. ALSO THERE MIGHT BE A DIFFERENTIAL BETWEEN ON & OFF SETTINGS.

(SP2) DUE TO THE INCREASED FAN MOTOR LOADING WHEN A UNIT OPERATES WITHOUT A SPRAY PUMP, THE DRY MODE OPERATION SHOULD ONLY BE USED ON UNITS WHOSE DRIVE SYSTEMS HAVE BEEN SPECIFICALLY DESIGNED FOR SUCH APPLICATIONS.

COOLING TOWER CONTROLS

ORDER NO: U1502935-012 Page 4 of 6

DATE: 12/02/2014

BALTIMORE AIRCOIL COMPANY

FOR SUBMITTAL PURPOSES ONLY

DRAWING NUMBER: **BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B**

REV **1**

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SHIELDED CABLE

COIL MOTOR STARTER OR MANUAL MOTOR PROTECTOR

GFP (L) (N) GROUND PROTECTION RELAY

CRxx COIL CONTROL RELAY

TRxx COIL TIMING RELAY

TRANSFORMER

FUSE

INDICATING LIGHT

MOMENTARY PUSHBUTTON

SELECTOR SWITCH

TS (R) (Y) (B) THERMOSTAT

LS (R) (Y) (B) FLOAT SWITCH

SV SOLENOID VALVE

(1) (3) NOTC DELAY ON NORMALLY OPEN TIMING CONTACT

(1) (3) DELAY OFF NORMALLY CLOSED TIMING CONTACT

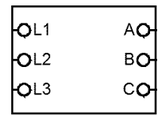
XX DRY CONTACT

SXX LIMIT SWITCH

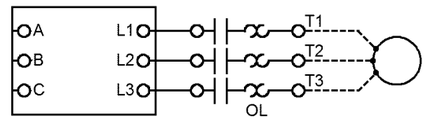
TERMINAL POINT IN VFD

LOCAL TERMINAL POINT

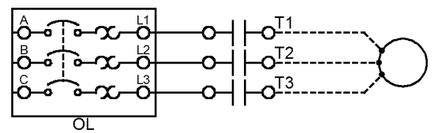
FIELD WIRING



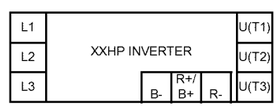
CIRCUIT BREAKER



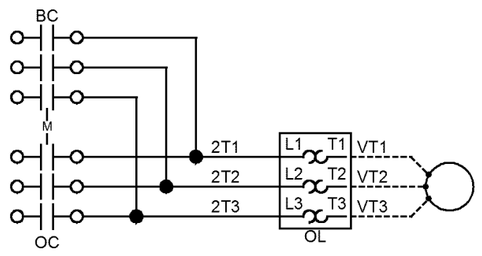
COMBINATION CIRCUIT BREAKER MOTOR STARTER WITH OVERLOAD



COMBINATION MANUAL MOTOR CONTROLLER/CONTACTOR INTEGRAL OVERLOAD



VARIABLE FREQUENCY DRIVE



VARIABLE FREQUENCY DRIVE BYPASS CONTACTORS

BASIN HEATER

GROUND PROTECTION SENSOR

VFD NOTES

1. ENCLOSURE AND MOTOR(S) MUST BE GROUNDED. SEE INSTRUCTION MANUAL
2. AUX CONTACTS RATED 10 AMPS AT 600 VAC
3. REFER TO VIBRATION CUTOUT SWITCH DRAWING IN BAC SUBMITTAL PACKAGE FOR FIELD WIRING
4. FOR MORE DETAILED INFORMATION, VISIT BALTIMOTREAIRCOIL.COM
5. NOTE: COMMUNICATION CARDS CAN BE SUPPLIED WITH THE DRIVE OR FIELD OPTION. REFERENCE USER MANUAL AND OPTION CARD MANUAL
6. OPTXX SLOT E (OPTIONAL COMM CARDS)

COIL/RELAY TERMINOLOGY
(SOME ARE OPTIONAL)

IC	VFD INPUT CONTACTOR	CRP1	COIL RELAY FOR PCD
OC	VFD OUTPUT CONTACTOR	CRP2	PCD RELAY ENABLE FAN&PUMP MODE
BC	VFD BYPASS CONTACTOR	GFP	GROUND FAULT INTERPOSING RELAY
AUX	AUXILLARY STARTER		
SP1	SPRAY PUMP #1 CONTACT	CRGF	GROUND FAULT RELAY COIL
SP2	SPRAY PUMP #2 CONTACT	CRHL	HEATER CIRCUIT SHUTDOWN INTERLOCK
HC1	BASIN HEATER COIL #1	PR1	VCOS PULSE RELAY
HC2	BASIN HEATER COIL #2		
CRV1	VCOS COIL FOR FAN&PUMP RUN ENABLE		
HAND	FAN&PUMP HAND MODE		
TDR1	AUX->VFD/BYPASS		
DRIVE READY	VFD READY MODE		
DRIVE POWER	SWITCH TO POWER I-CONTACTOR		
TCPD	VFD OUTPUT FOR PCD ENABLE		
TCSP	VFD OUTPUT FOR SPRAY PUMP ENABLE		

COOLING TOWER CONTROLS

ORDER NO: U1502935-012 Page 5 of 6

DATE: 12/02/2014

BALTIMORE AIRCOIL COMPANY

FOR SUBMITTAL PURPOSES ONLY

DRAWING NUMBER: BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B

REV 1

WLLFOIA4312 - 001 - 0018051

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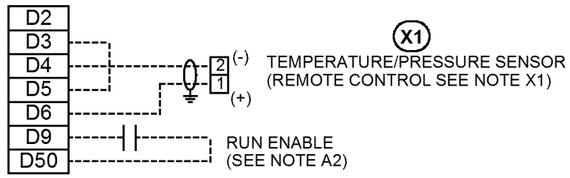
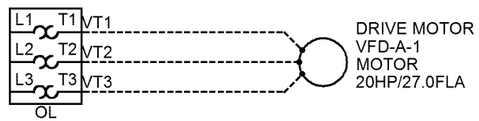
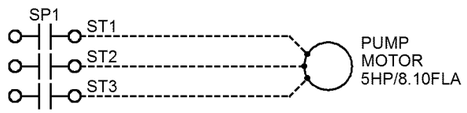
24Vdc

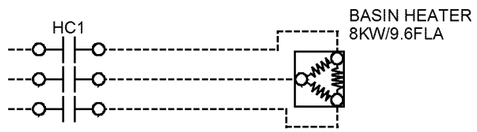
(RED)



460Vac

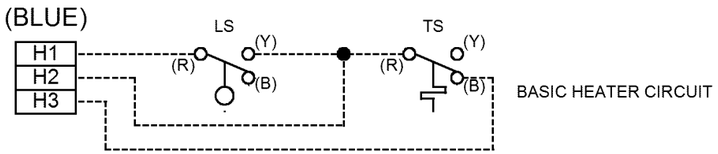






120Vac

(BLUE)



IMPORTANT!!
NOT ALL CIRCUITS MAY HAVE BEEN INCLUDED ON THIS PAGE. PLEASE DOUBLE CHECK PREVIOUS PAGES FOR ADDITIONAL FIELD WIRING

GENERATED WITH VERSION 1.5.5

COOLING TOWER CONTROLS

ORDER NO: U1502935-012 **Page 6 of 6**

DATE: 12/02/2014

BALTIMORE AIRCOIL COMPANY

FOR SUBMITTAL PURPOSES ONLY

DRAWING NUMBER: **BACCC-C-V1N-A0A-1-A0A-A0A-0-1J1-1J-A-3-0Z-A-A-B**

REV **1**

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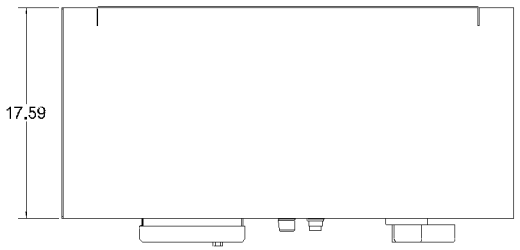
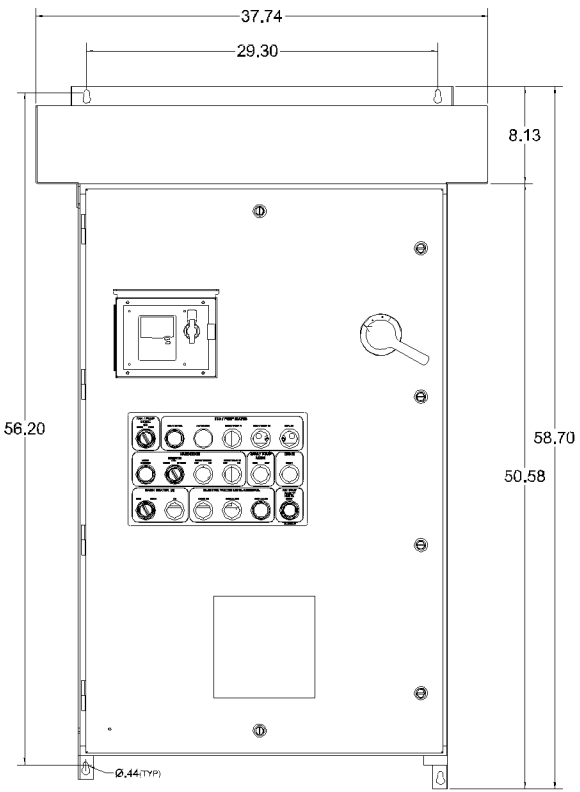
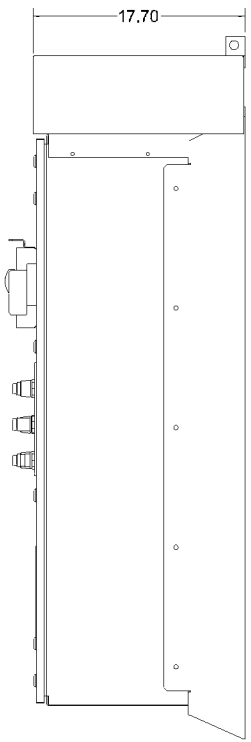
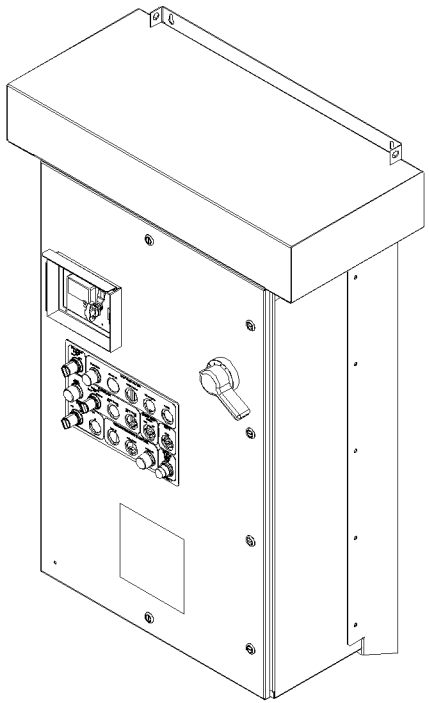




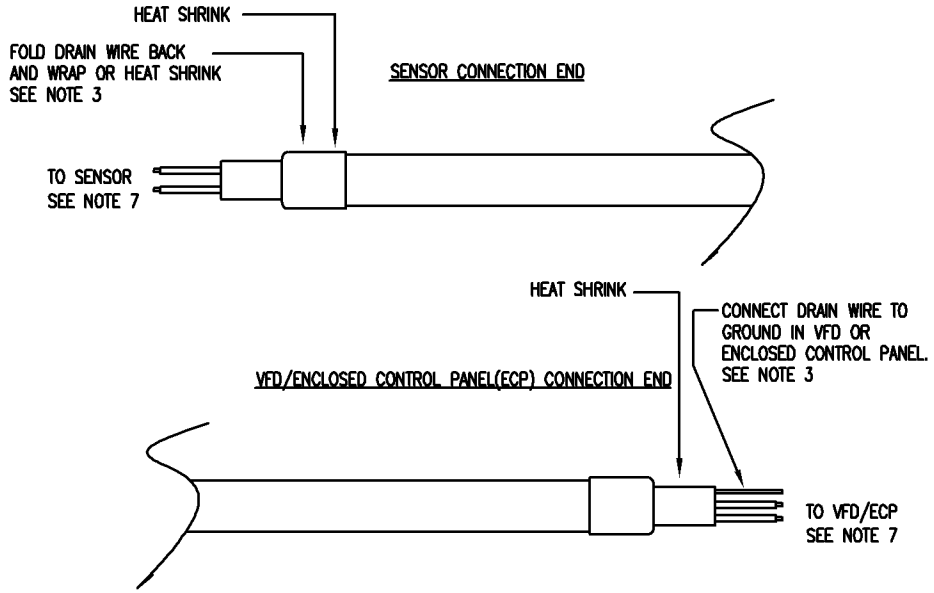




Ref: 84-32612

MOTOR CONTROLS ORDER NO: DATE:	Baltimore Aircoil	DIMENSIONAL FOR EATON COMMON BOX NEMA 3R MILD AND 304 SST STEEL DRAWING NUMBER: BAC-C50-39189-1 REV 1

REQUIRED FIELD CONNECTION

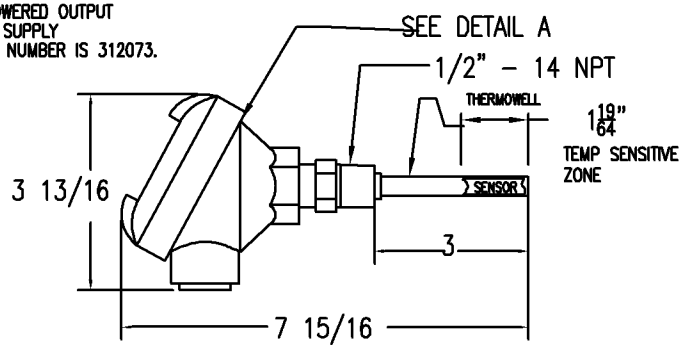


NOTES:

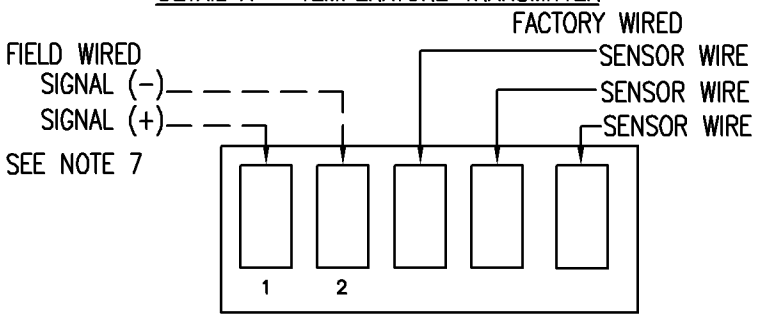
1. DEFAULT SENSOR RANGE: 0–200°F/4–20mA 10–30VDC LOOP POWERED TRANSDUCER.
2. USE ONLY TWISTED SHIELDED CABLE FOR SENSOR WIRING.
3. GROUND SIGNAL CABLE DRAIN WIRE AT VFD OR ENCLOSED CONTROL CONNECTION END ONLY. GROUNDING CABLE AT BOTH ENDS COULD CREATE A GROUND LOOP CAUSING A SIGNAL ERROR.
4. FOLLOW NATIONAL ELECTRICAL CODE AND LOCAL CODES FOR INSTALLTION AND WIRING OF TEMPERATURE SENSOR.
5. DO NOT ROUTE TEMPERATURE SENSOR CABLE WITH WIRES CARRYING MORE THAN 150V IN VFD OR ENCLOSED CONTROL PANELS.
6. INSTALL SENSOR IN LEAVING WATER OR FLUID PIPING WITH TEMPERATURE SENSITIVE ZONE LOCATED IN THE MIDDLE OF FLOW STREAM.
7. ALL FIELD WIRING BY OTHERS.
8. STAINLESS STEEL THERMOWELL CAN BE INSERTED DIRECTLY INTO THE FLUID STREAM. THE SENSING PROBE MAY BE REMOVED WITHOUT BREAKING THE FLUID SEAL.

OPTIONAL BAC FACTORY TEMPERATURE SENSOR

FACTORY CALIBRATED 0–200°F TEMPERATURE RANGE
4–20mA, LOOP POWERED OUTPUT
10–30VDC POWER SUPPLY
SENSOR BAC PART NUMBER IS 312073.



DETAIL A – TEMPERATURE TRANSMITTER



ORDER NO: U150293512	Baltimore Aircoil	TEMPERATURE SENSOR INSTALLATION AND FIELD CONNECTION DRAWING
DATE: 12/2/2014		DRAWING NUMBER: BAC-12623 — D

Attachment E:

Glycol Material Safety Data Sheet

Material Safety Data Sheet

MSDS Revision Date: 12/17/14
Page 1 of 5
PRODUCT: PROPYLENE GLYCOL INH 35% RED

BRENNTAG

1. Product and Company Identification

Product Identity: PROPYLENE GLYCOL INH 35% RED	Chemical Formula: mixture Molecular Weight: mixture
Synonyms: Propylene glycol inhibited 35% red	

Brenntag Mid-South Inc.
1405 Hwy 136 W
Henderson, KY 42420

Technical Information: 270-830-1200
Emergency Number: 800-424-9300 (CHEMTREC)
Emergency Number: 703-5273887 (International)

2. Hazards Identification

Emergency Overview

WARNING!

INHALATION: No significant adverse effects to health would be expected to occur from inhalation with normal use of this product due to its low volatility and vapor pressure.

EYE CONTACT: Contact with eyes may cause transient eye redness if not washed out and left in the eyes for an extended period of time. No corneal involvement or visual impairment would be expected.

SKIN CONTACT: Skin contact may cause transient redness if not washed off and left on the skin for an extended period of time. This irritant effect would not be expected to result in permanent damage. Skin contact may cause sensitization and allergic skin reaction in small proportion of individuals.

INGESTION: Ingestion may cause gastrointestinal discomfort with any or all of the following symptoms: nausea, vomiting, lethargy or diarrhea.

PRIMARY ROUTES OF ENTRY: Ingestion.

CHEMICAL LISTED AS CARCINOGEN OR POTENTIAL CARCINOGEN: NTP/No IARC/No OSHA/No

3. Composition/Information on Ingredients

CAS#	Chemical Name	Percent by Weight
57-55-6	Propylene Glycol	33 – 35
7758-11-4	Dipotassium hydrogen phosphate	< 2
7732-18-5	Water	63 – 66

IMPORTANT: While Brenntag believes the information contained herein to be accurate, Brenntag makes no representation or warranty, express or implied, regarding, and assumes no liability for, the accuracy or completeness of the information. The Buyer assumes all responsibility for handling, using and/or reselling the Product in accordance with the applicable federal, state, and local law. This MSDS shall not in any way limit or preclude the operation and effect of any of the provisions of Brenntag's terms and conditions of sale.

Material Safety Data Sheet
MSDS Revision Date: 12/17/14

PRODUCT: PROPYLENE GLYCOL INH 35% RED

BRENNTAG

4. First Aid Measures

INHALATION: Remove victim to fresh air. Give artificial respiration if not breathing. Get prompt medical attention.

EYE CONTACT: Flush eyes thoroughly with water while holding eyelids open. Get medical attention if irritation develops.

SKIN CONTACT: Wash affected area with plenty of water and remove contaminated clothing. Wash clothing before reusing. Get medical attention for irritation.

INGESTION: Immediately drink water to dilute. Consult a physician if symptoms develop.

5. Fire Fighting Measures

FLASH POINT (METHOD USED): None **FLAMMABLE LIMITS (% BY VOLUME):** None established

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical, alcohol foam, water spray.

SPECIAL FIRE FIGHTING PROCEDURES: Fire fighters should wear protective clothing including a self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None.

6. Accidental Release Measures

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Remove all sources of ignition. Personnel with protective clothing should dike and contain spilled material. Remove to containers for recovery/disposal. Soak up residue (small spill) with inert absorbent. Shovel or sweep up and place in containers for disposal.

7. Handling and Storage

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store in a cool, dry, well-ventilated area.

OTHER PRECAUTIONS: Avoid contact with eyes, skin, or clothing. Do not take internally. Upon contact with skin and eyes, flush immediately with water. Avoid breathing mist or vapor. Prolonged or repeated skin contact may cause irritation.

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Material Safety Data Sheet
MSDS Revision Date: 12/17/14

PRODUCT: PROPYLENE GLYCOL INH 35% RED

BRENNTAG

8. Exposure Controls/Personal Protection

CAS NUMBER	CHEMICAL NAME(S)	WT %	THRESHOLD LIMIT VALUES (UNITS)			
			OSHA:		ACGIH:	
			PEL	STEL	TLV	STEL
57-55-6	Propylene Glycol	33 – 35	— NONE ESTABLISHED —			
7758-11-4	Dipotassium hydrogen phosphate	< 2	— NONE ESTABLISHED —			
7732-18-5	Water	63 – 66	— NONE ESTABLISHED —			

RESPIRATORY PROTECTION: Respiratory protection not normally required.

VENTILATION: Use general exhaust ventilation.

PROTECTIVE GLOVES: Impervious.

EYE PROTECTION: Goggles.

OTHER PROTECTIVE EQUIPMENT: Eye wash fountain and safety shower. Clothing to prevent prolonged or repeated skin contact.

9. Physical and Chemical Properties

BOILING POINT °F (°C): 219 °F (103.9 °C)

SPECIFIC GRAVITY (H_2O=1): 1.035

VAPOR DENSITY (AIR =1): 0.6

PERCENT VOLATILE BY VOLUME (%): > 65%

VAPOR PRESSURE (mmHg): 68 °F/20 °C ≈ 17.5

SOLUBILITY IN WATER: Complete

EVAPORATION RATE (Butyl Acetate = 1): ≈ 0.24

APPEARANCE AND ODOR: Clear, red liquid with mild odor.

10. Stability and Reactivity

STABILITY: Stable.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Extreme heat.

INCOMPATIBILITY (MATERIALS TO AVOID): Strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide and carbon dioxide

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Material Safety Data Sheet
MSDS Revision Date: 12/17/14

PRODUCT: PROPYLENE GLYCOL INH 35% RED

BRENNTAG

11. Toxicological Information

Acute Toxicity - Lethal Doses
LD50 (Oral) Rat 22,000 MG/KG BWT; LD50 (Skin) Rabbit. 20,800 MG/KG BWT
Irritation: Not a skin irritant. Repeated or prolonged contact with skin may cause dermatitis. May cause minor eye irritation. Effects of eye irritation are reversible.
Sensitization: Not expected to cause sensitization by skin contact, however skin reactions of unknown etiology have been described in some hypersensitive individuals following topical application.
Target Organ Effects: Skin. Repeated or prolonged contact with skin may cause defatting and drying of the skin which may result in dermatitis.
Repeated Dose Toxicity: No adverse systemic changes were reported in rats or dogs following repeated dietary exposure to high concentrations of propylene glycol. Cats responded with species-specific hematological changes (Heinz body formation) yet all other tissues were unaffected. No systemic effects, but mild eye and nasal irritation were noted in rats following sub-chronic exposure to high concentrations of propylene glycol aerosol. Overall propylene glycol is of low inherent toxicity following repeated oral or inhalation exposure.
Reproductive Effects: No adverse effect on reproductive performance was seen in male and female mice exposed continuously to high doses of propylene glycol in drinking water for up to 3 months.
Developmental Effects: Results from studies in pregnant rats, mice, hamsters and rabbits demonstrate that propylene glycol is not teratogenic or fetotoxic.
Genetic Toxicity: Negative for genotoxicity both in vitro and in vivo tests.
Carcinogenicity: No increase in tumors was noted in rats and dogs exposed to high concentrations of propylene glycol via the diet for up to 2 years. The incidence of skin tumors was unaltered in mice following dermal application over a lifetime. Not listed by IARC, NTP, or OSHA.

12. Ecological Information

Acute toxicity to fish: LC50 / 96 HOUR fathead minnow 51,400 mg/l; LC50 / 96 HOUR salmon 51,600 mg/l; Acute toxicity to aquatic invertebrates; EC50 / 48 HOUR Daphnia magna. 43,500 mg/l; EC50 / 48 HOUR saltwater mysid. 27,300 mg/l

Toxicity to aquatic plants: EC50 / 72 HOUR Freshwater Algae. 24,200 mg/l; EC50 / 72 HOUR Marine algae 19,300 mg/l

Chronic toxicity to fish: Summary: No Data Available.

Chronic toxicity to aquatic invertebrates: IC25 / waterflea. 13,470 mg/l
Summary: A three-generation reproductive study.

Environmental Fate and Pathway: Mobility: Transport between environmental compartments: Environmental releases of propylene glycol will tend to partition to water and soil, with little potential for evaporation.
Persistence and Degradability: Biodegradation: Readily biodegradable in aerobic conditions. There is evidence that it is degraded under anaerobic conditions.

Bioaccumulation: This material is not expected to bioaccumulate. BCF < 1.5

Environmental Fate: When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material is expected to leach into groundwater. When released into water, this material is expected to readily biodegrade. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.

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Material Safety Data Sheet
MSDS Revision Date: 12/17/14

PRODUCT: PROPYLENE GLYCOL INH 35% RED

BRENNTAG

13. Disposal Considerations

WASTE DISPOSAL METHOD: Incinerate in a furnace. Disposal is to be in accordance with federal, state, and local regulations

14. Transport Information

PROPER SHIPPING NAME: Not DOT regulated.

HAZARD CLASS: N/A **UN/NA:** N/A **PACKING GROUP:** N/A

D.O.T. LABEL REQUIRED: N/A **REPORTABLE QUANTITY OF PRODUCT:** N/A

15. Regulatory Information

TSCA (Toxic Substance Control Act): All components of this product are listed on the TSCA inventory.

SARA TITLE III: HAZARD CLASSIFICATIONS: Acute: no Chronic: no Fire: no Pressure: no Reactivity: no

NAME	CAS/313 Category Codes	Section 302 (EHS) TPQ	Section 304 EHS RQ	CERCLA RQ	Section 313	RCRA CODE	CAA 112(R) TQ
n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

16. Other Information

HMIS HAZARD RATING: Health 0 Flammability 1 Reactivity 0

VOC CONTENT (lbs/gal): n.a.

This MSDS is provided as an information resource only. It should not be taken as a warranty or representation for which Brenntag assumes legal liability. While Brenntag believes the information contained herein is accurate and compiled from sources believed to be reliable, it is the responsibility of the user to investigate and verify its identity. The buyer assumes all responsibility for using and handling the product in accordance with applicable international, federal, state, and local regulations.

Brenntag Mid-South Inc.
1405 Hwy 136 W
Henderson, KY 42420

PREPARED BY: APPROVED BY:

C:\RD1\WORD\MSDS\PG Inh 35 Red

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Attachment F:

Google Earth Historical Aerial Photographs from March and November 2002

Google earth

feet 900
meters 200

March, 2002 Aerial Photograph

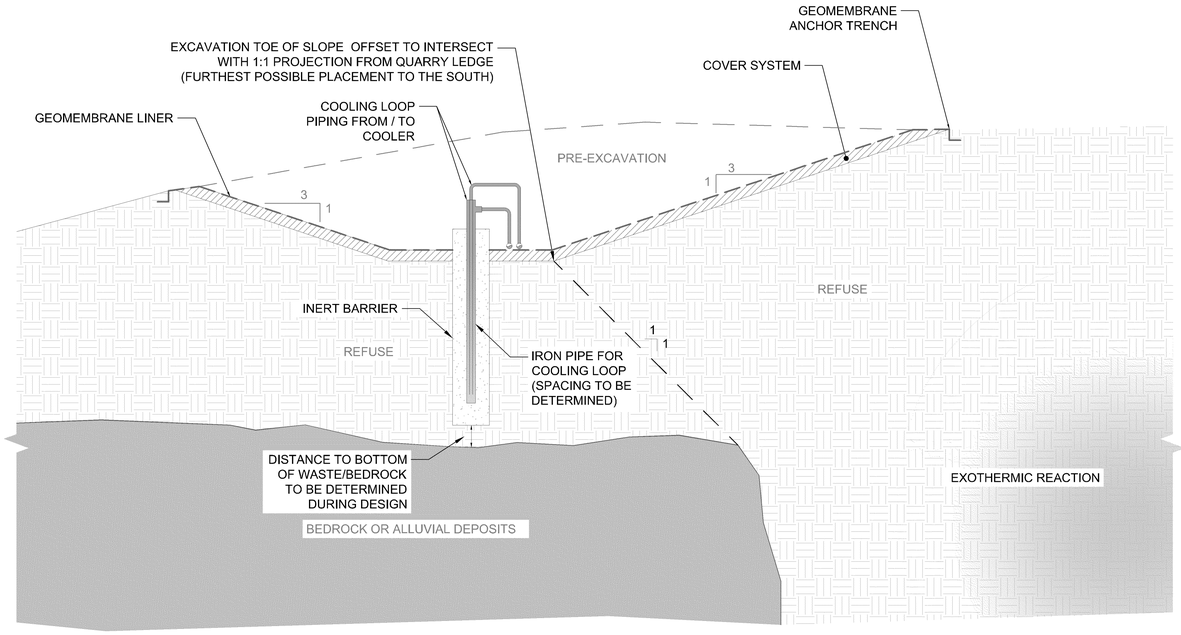
Google earth

feet 900
meters 200

November 2002 Aerial Photograph

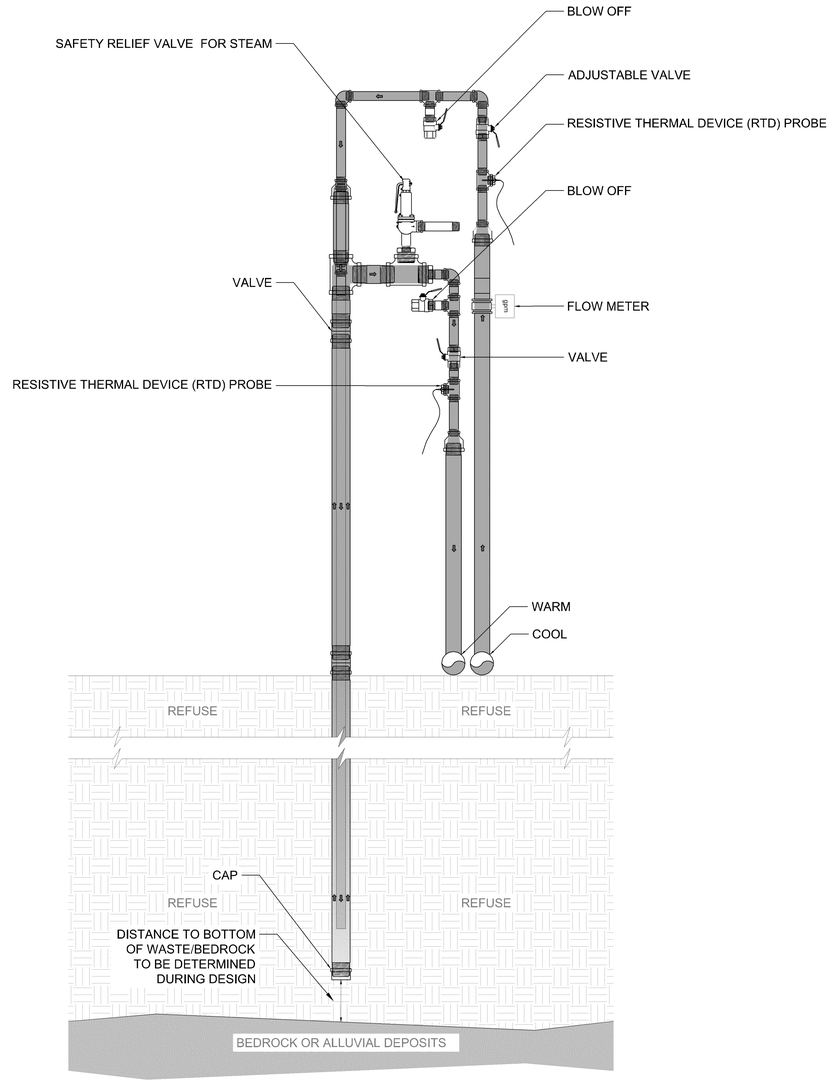
Attachment G:

Revised Drawing Sheet No. 16



1/16 OPTION 1 AND 3 - TYPICAL INERT BARRIER

NOT TO SCALE



2/16 OPTION 4 - DRILLED OR DRIVEN COOLING POINT

NOT TO SCALE

THE DRAWINGS INCLUDED WITHIN THIS PLAN SET ARE NOT DESIGN NOR CONSTRUCTION LEVEL DRAWINGS. THEY ARE INTENDED FOR ILLUSTRATIVE PURPOSES ONLY.

BRIDGETON LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL ISOLATION BARRIER ALTERNATIVES ANALYSES REPORT	Engineering for a Better World FEEZOR ENGINEERING, INC.	OCTOBER 2014 DESIGNED BY: PML APPROVED BY: DRF REV. 1 OCT 2015
DETAILS			DRAWING NO.: **016**
PROJECT NUMBER: BT-032	FILE PATH: C:\Users\Adam Fin\Dropbox (Feezor Engineering)\AF - EPA Barrier Alternatives Report - Revised 10-4-14 - Copy\BT-032-016 (Barrier Conceptual Detail) Rev 1 10-8-15.dwg		REVISION DATE

Attachment H:

August 2013 Heat Flux Calculations

P.J.Carey & Associates, P.C.

CLIENT Bridgeton Landfill **CALCULATIONBY** **Peter J. Carey**

PROJECT **Bridgeton Contingency**

JOB No 179.003

DATE **8-11-13**

OBJECT: Estimation of heat flow to the north of the heat front that is flowing from the front area toward the quarry narrow area (line of tmp 1-4)

Reference: Yoshida, H., Rowe, R.K.,"Consideration of Landfill Liner Temperature" Proceedings Ninth International Waste Management and Landfill Symposium, Sardinia October 2003. Used for source of approximate heat conductivity and heat capacity of solid waste materials

General Approach

Use the temperature gradient as measured in the tmps and the rate of warming per month to achieve an estimate of the energy being conveyed toward the quarry narrow area. Base the rate of temperate rise on the monthy advance of the heat front, which based on both settlement front movment and the time between Jan 15 and June 15 (approximately 150 days for the front to advance from TMP 8 to TMP-7R(a northern distance of 42 feet) or $\frac{42\text{ft}}{150\,\text{day}} = 0.28\,\frac{\text{ft}}{\text{day}}$. Use a value of 0.3 feet per day. This would amount to the same 9 feet per month u. For gradient on the cool side of the heat front use the values determined in March based on the warmest 60 foot of each tmp, this w: $\text{Gradient} := \frac{0.84\,°\text{F}}{\text{ft}}$. Behavior measured at the site has not indicated any higher flux rates at present, for example the gradient between TMP-14 and TMP-11 is less than 0.4 per foot using maximum temperatures at present.

Warming of Front Zone

At the heat front the change in temperature does not typically change more than $\Delta_{\text{temp}} := 10\,\text{K}$ (approximately 18 deg F) per month and the typical zone being heated this amount is less than 80 feet thick. The heat energy involved in this warming is equal to the mass of the waste times the total heat capacity times the change in temperature. Using the upper value for heat capacity for the waste from the above reference

$$\text{WarmingEnergy} := \left(60\text{ft}\cdot 9\,\frac{\text{ft}}{30\,\text{day}}\cdot 2000\,\frac{\text{joule}}{\text{kg}\cdot\text{K}}\cdot 63\,\frac{\text{lb}}{\text{ft}^3}\cdot 10\text{K}\right) = 119.068\,\frac{1}{\text{ft}}\,\text{W}$$ per ft width of front

$$\text{Warmingheatflux} := \frac{\text{WarmingEnergy}}{100\text{ft}} = 12.816\,\frac{\text{W}}{\text{m}^2}$$ if a 100 foot deep removal system is used

where 2000 joule per kg per deg K is the heat capacity of the waste

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Gradient Flux Rate

The heat flux associated with maintaining the gradient on the cool side of the reaction is computed using the thermal conductivity of the waste.

$k_e := 0.96 \frac{joule}{m \cdot sec \cdot K}$ for saturated waste use an unit area $A := 1m^2$

converting the gradient to deg k $Gradient := 0.467 \frac{K}{ft}$

$GradientHeat := Gradient \cdot k_e$ $GradientHeat = 1.471 \frac{W}{m^2}$

the computed total flux is then

$$GradientHeat = Warmingheatflux = 14.287 \frac{W}{m^2}$$

a design for 50% greater than this value would represent the something that would result in cooling by also removing some stored heat in the waste. It should be noted that other heat losses are being ignored in this simplified approach.

$14.8 \cdot 1.5 \frac{W}{m^2} = 22.2 \frac{W}{m^2}$

this could be used as a limiting value that the system may eventually need to be able to handle, including whatever added points are used for extraction south of whatever "barrier line" is utilized. The total energy removal is computed by using the depth of the heat zone times the width of treatment. Note that this value is based on the faster moving portion of the front.

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Attachment I:

Bird Management and Control Plans

Bird Management and Control Plans for Various Barrier Options at West Lake Site, Bridgeton Landfill, St. Louis, MO.

Prepared by

Rolph A. Davis, Ph.D
Executive Chairman
LGL Limited
King City, ON
radavis@lgl.com

For

Bridgeton Landfill, L.L.C.
13570 Saint Charles Rock Road
Bridgeton, MO
63044

LGL Report FA0030-1

October 6, 2015

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Introduction

Efforts are currently under way at the West Lake/Bridgeton Landfill site (the "Landfill") to address the potential impacts of a subsurface smoldering reaction or event ("SSR" or "SSE") currently taking place in the South Quarry area of the Bridgeton Landfill. A by-product of some of the options currently being considered to address the SSR is the digging-up and subsequent exposure of previously deposited municipal solid waste. This could attract birds that might pose a threat to the safety of aircraft using the nearby Lambert-St. Louis International Airport (the "Airport"). The relative hazard risks associated with each of the options were addressed in a document prepared by Rolph A. Davis (7 October 2014) that accompanied the technical evaluation of the various engineering options. Agency reviewers have requested that more detailed bird control plans be prepared to address any issues associated with each option. Those plans are presented below.

Review of Proposed Options

Five possible options have been identified. The key elements of each option are summarized here proceeding from lowest potential to attract hazardous birds to highest potential. Terminology is the same as in previous submissions.

No Action Alternative

The 'no action alternative' will not result in any changes in the attractiveness of the site to birds.

Option 4: Heat Extraction Barrier

This option does not involve excavation of any previously deposited waste. The option includes drilling and other surface activities.

Option 1: Inert Barrier along Alignment 1

This option involves the excavation of ~52,000 yds^3 of old municipal solid waste (msw) that was deposited several years ago. The excavated material would be deposited on a different part of the site. The excavation area would be exposed for about 39 weeks. It is likely that most of the edible organic content of this waste will have disappeared. However, the mere activity of digging up the waste and depositing it elsewhere on the site will attract some gulls that recognize the site as an active landfill. A full bird control program would be required for this option.

Option 3: Inert Barrier along Alignment 3

This option is similar to Option 1 but involves the excavation of slightly more waste, ~63,500 yds^3. The excavated area would be exposed for about 48 weeks. The msw excavated here was originally deposited more recently than the waste in the previous option. It is more likely that this waste would include some edible waste. A full bird control program would be required for this option.

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Option 2: Air Gap Barrier

This option would involve excav ation of ~540,000 yds^3 of waste. Because of the large amount of waste, bird control would be a major undertaking. Ho wever, the option is no longer being considered due to technical problems with the approach.

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Bird Control Plans

Bridgeton Landfill will implement an appropriate bird control and monitoring plan for each Barrier Option when work on that proposed project begins. The intensity of the plan will be a function of the option selected, because the options have different probabilities of attracting hazardous birds to the excavated waste and the associated construction activities. The bird control programs for each of the options are presented below.

No Action Alternative

No additional birds would be attracted in the No Action Alternative. However, the existing activities at the landfill will continue and have some possibility to attract birds. There is an existing Bird Hazard Monitoring and Mitigation Plan in place. Assuming that plan continues to be carried out, then bird hazards are not anticipated. Therefore, no additional Bird Control Plan is proposed.

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Heat Extraction Barrier – Option 4: Bird Control Plan

This option does not involve the excavation of waste and should not create an attraction to birds. However, there will be construction and drilling activi ties and other surface activities. These could attract curious birds, primarily gulls, looking for food. Bird control under this option would be conducted by a single full-time bird controller. That controller would be on site five days per week to determine whether any birds are attracted to t he site. If potentially hazardous species are present, they will be dispersed using pyrotechnics. Monitoring and control of potentially hazardous birds will be the principal occupation of this controller.

The controller will receive training from USDA Wildlife Service s staff. In addition, the controller will receive specialized landfill bird control training from an experienced biologist from LGL Limited. To provide redundancy in the event of sickness or other absence, another landfill staff member will also receive the training so that he/she can insure that there are no gaps in monitoring coverage.

Weekly reports would be prepared and submitted to the Airport and other relevant agencies. The reports would document the time that controllers spent on site, the numbers and species of birds recorded at th e site, and the numbers of pyrot echnic shots, if any, that were fired that week. The reports would be supervised by LGL Limited to m onitor any trends that would indicate that future problems might develop.

The final details of the bird control plan will be determined in coordination with the Airport during the engineering phase of the project. The design phase of the bird control program will be conducted in conjunction with appropriate personnel from the Airport and from USDA – Wildlife Services and the control program will require agreement by the Airport.

Failure criteria would be establi shed to define levels of bird activity at the site that would require notification to the Airport and an intensification of the bird control program. Intensification would involve the addition of bird controllers and possible lethal intervention by USDA personnel.

Standard procedures for orderi ng and storing the pyrotechnics, caps and pistols will be implemented before the operation begins. Appropriate storage is required by ATF rules that apply to private sector operators.ppAropriate safety equipment will be provided and adequate safety training will be given.

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Inert Barrier along Alignment 1: Bird Control Plan

This Barrier Option involves excavation of ~52,000 yds³ of waste. The excavation area would be open for about 39 weeks. It is quite likely that the municipal solid waste (msw) excavated during Option 1 is old enough that the waste will have lost most of its organic content and be unattractive to birds. However, whether that will be the case will not be known until the waste is excavated. To be on the safe side, it is best to assume that the waste will still contain some organic matter that is attractive to birds. Therefore, a well-designed bird control program will be in place when the excavation begins.

Elements of Successful Control Program

The key to a successful control program is to have controllers who are well-trained by experienced professionals and overseen by those professionals. As requested by the Airport, controllers would take the basic bird mitigation and monitoring course provided by the wildlife professionals at USDA-Wildlife Services. This would ensure that controllers have been advised on issues and approaches of specific interest and concern to the Airport. In addition, the controllers would have specialized training in landfill bird control procedures provided by a biologist from LGL Limited. The biologist from LGL Limited has wide experience with bird control at many large msw landfills and will focus on the key operational factors that make landfill bird control successful.

The control program would involve continuous coverage with a controller on duty at all times when there is uncovered waste present, including weekends. If any birds appear and attempt to feed on the waste, they will be frightened off using properly-applied procedures based on using standard pyrotechnics. Because the first arriving birds will be scared away, numbers of birds will not increase and will not become a problem. This is particularly important for control of gulls. These techniques have been used successfully at many major active msw landfills (e.g. Illinois, New Jersey, Texas, Colorado) under the direction of LGL Limited biologists. To insure that control coverage is continuous, a minimum of two controllers would be needed to cover long days and weekends. A third staff member will be trained in bird control to act on a short-term basis in the event of illness or other absence by one of the regular controllers.

Bird Species

The bird species of most concern in the St. Louis area are Ring-billed Gull, Herring Gull, Turkey Vulture, American Crow, and European Starling. These species are fairly large and/or occur in dense flocks that can pose a threat to turbine-powered aircraft. The species feed at landfills and can pose a hazard to aircraft safety in some situations. Gulls are of most concern because of their well-known propensity to actively feed at landfills. The control program will focus on gulls. Turkey Vultures and crows generally avoid humans and operating equipment and do not attempt to feed under these circumstances. Turkey Vultures are the only birds in this region that have a sense of smell but they do most of their hunting by sight. Starlings can occur in large flocks and are more common in agricultural areas than at landfills. None of these species occur at landfills at night; therefore, control is only necessary during the day.

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There will be a seasonal aspect to the bird control program. Most gulls are at nesting areas further north during the late spring though early autumn. Large numbers arrive from the north during late fall and winter. Turkey Vultures leave the area during winter. Flocks of starlings tend to occur at landfills during the fall and winter. Therefore, during spring and summer, the main species of concern will be Turkey Vultures and they are easily controlled. During fall and winter, gulls, crows and starlings are present in the area and control efforts will be more intensive. The short days during this period assist in reducing the numbers of controllers needed to provide complete coverage.

During the fall and winter, control coverage will be necessary from dawn to dusk because gulls often feed at landfills before and after the daily operating hours of the landfills. During the long days of summer, gulls are absent and Turkey Vultures are the key species of concern. Control of vultures need only be done before the operations start in the morning and after the operations conclude for the day. During the day, vultures will not attempt to feed at the active working areas where humans and equipment are present.

If the waste relocation area is distant from the excavation area, it may be necessary to have an additional controller at the relocation area. That will bethe case if the excavated waste contains substantial organic matter that is attractive to birds. That will be monitored at the beginning of the operation and a third controller added, if necessary. The control team will have access to a vehicle (ATV or pick-up truck).

Reporting

Weekly reports would be prepared and submitted to the Airport and other relevant agencies. The reports would document the time that controllers spent on site, the numbers and species of birds recorded at the site, and the numbers of pyrotechnic shots that were fired that week. The reports would be supervised by LGL Limited to monitor any trends that would indicate that future problems might develop.

Implementation

The final details of the bird control plan would be determined in coordination with the Airport during the engineering phase of the project that will occur after the Barrier Option has been selected. The design phase of the bird control program will be conducted in conjunction with appropriate personnel from the Airport and from USDA – Wildlife Services and the control program will require agreement by the Airport.

Failure criteria would be established to define levels of bird activity at the site that would require notification to the Airport and an intensification of the bird control program. Intensification would involve the addition of bird controllers and possible lethal intervention by USDA personnel.

Standard procedures for ordering and storing the pyrotechnics, firing caps, and pistols will be implemented before the operation begins. Appropriate storage is required by ATF rules that

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apply to private sector operato rs. Appropriate safety equipmen t will be provided and adequate safety training will be given.

Conclusion

In conclusion, in the unlikely event that the excavated waste c ontains edible organic material, bird populations can be successfully controlled and t here should not be an increase in bird strike risk to aircraft using the Lambert-St. Louis International Airport.

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Inert Barrier along Alignment 3: Bird Control Plan

This Barrier Option involves excavation of ~63,500 yds³ of waste. The excavation area would be open for about 48 weeks. The waste excavated in this option is newer than in Option 1 and is more likely to still contain organic matter. It may or may not be attractive to birds. Given this uncertainty, it is prudent to assume that the waste will still contain some organic matter that is attractive to birds. Therefore, a well-designed bird control program will be in place when the excavation begins.

Elements of Successful Control Program

The key to a successful control program is to have controllers who are well-trained by experienced professionals and overseen by those professionals. As requested by the Airport, controllers would take the basic bird mitigation and monitoring course provided by the wildlife professionals at USDA-Wildlife Services. This would ensure that controllers have been advised on issues and approaches of specific interest and concern to the Airport. In addition, the controllers would have specialized training in landfill bird control procedures provided by a biologist from LGL Limited. The biologist from LGL Limited has wide experience with bird control at many large msw landfills and will focus on the key operational factors that make landfill bird control successful.

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There will be a seasonal aspect to the bird control program. Most gulls are at nesting areas further north during the late spring though early autumn. Large numbers arrive from the north during late fall and winter. Turkey Vultures leave the area during winter. Flocks of starlings tend to occur at landfills during the fall and winter. Therefore, during spring and summer, the main species of concern will be Turkey Vultures and they are easily controlled. During fall and winter, gulls, crows and starlings are present in the area and control efforts will be more intensive. The short days during this period assist in reducing the numbers of controllers needed to provide complete coverage.

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Conclusion

In conclusion, in the unlikely event that the excavated waste c ontains edible organic material, bird populations can be successfully controlled and t here should not be an increase in bird strike risk to aircraft using the Lambert-St. Louis International Airport.

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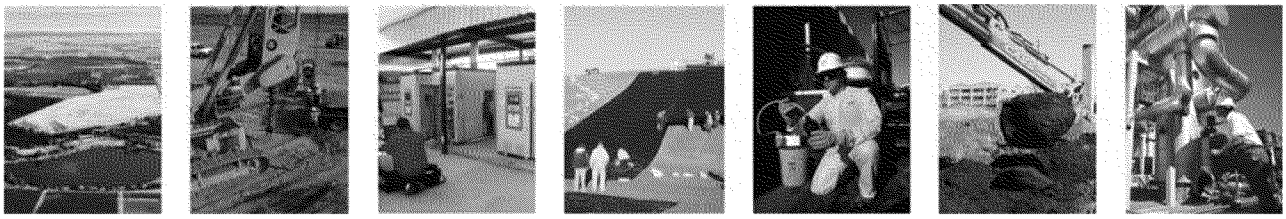
Attachment J:

Evaluation of Remedial Action Approaches for Hot Spot Removal, Bridgeton Landfill

SCS ENGINEERS



Evaluation of Remedial Action Approaches for Hot Spot Remediation

Presented to:

Bridgeton Landfill, LLC
13570 St. Charles Rock Road
Bridgeton, Missouri 63044
(314) 744-8166

Presented by:

SCS ENGINEERS
2060 Reading Road, Suite 200
Cincinnati, Ohio 45202
(513) 421-5353

September 9, 2015
File No. 23211003.04

Offices Nationwide
www.scsengineers.com

WLLFOIA4312 - 001 - 0018083

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Appendices

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1.0 INTRODUCTION

In their letter dated August 10, 2015, the Missouri Department of Natural Resources (DNR) requested that Bridgeton Landfill, LLC prepare a Corrective Measures Work Plan that includes:

> *"...a corrective action measure using inert gas injection as a "hot spot" treatment."*

At the Request of Bridgeton Landfill, LLC, SCS was tasked with conducting a review of the site's current remedial approach to remedy potential hot spots as well as evaluate inert gas injection as an additional measure in addressing potential hot spots in the North Quarry. This report evaluates the following two approaches for remediating a local subsurface oxidation event:

- Oxygen deprivation
- Inert gas injection

Appendix D of the November 2014 Corrective Action Plan describes the identification of and remedial actions for local subsurface oxidation (SSO). As described in Appendix D:

> *"Subsurface Oxidation Events (SSO) are common events that occur at many landfills that have active gas collection systems. These are local subsurface fires that are caused by a combination of subsurface conditions and well management. Unlike large subsurface reactions (which are extremely rare, do not require oxygen to propagate, and are quite different in nature), SSOs usually only involve a small area and a minimal number of gas wells."*

If the actions described in Appendix D of the November 2014 Corrective Action Plan are unsuccessful in controlling the SSO, inert gas injection may be implemented to remediate the SSO event.

2.0 OXYGEN DEPRIVATION

Appendix D of the Corrective Action Plan (attached to this document as Appendix A) describes the current approach for remediating an SSO by depriving it of oxygen. The actions to be taken include:

- Shutdown well(s) that is believed to have been the cause of the SSO.
- Shutdown all wells in surrounding area (within the approximately 300 feet of suspect well(s)).
- Cap or repair any item identified during the physical inspection that may be contributing to oxygen intrusion.

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- Carefully add additional cover to areas that show cap integrity issues if necessary. Work slowly and pay special attention to the ground surface as material placement commences.
    - During cover placement activities, there should be a minimum of two people available; the equipment operator, and a line-of-sight person on the ground that is responsible for watching the ground surface as the equipment operator places the soil.
    - Use a low ground pressure (LGP) machine, if available. If LGP machine is not available, use the lightest machine with the widest tracks available. Do not use rubber tired machine to place cover material.
    - Slowly push soil into the area and compact with the bucket or tracks of the equipment.

This approach is essential the industry standard for addressing SSOs. It is typically successful in controlling SSOs. The amount of time needed to achieve sufficient remediation to allow the landfill gas extraction well at and in the immediate vicinity of the SSO can vary.

3.0 INERT GAS INJECTION

Carbon dioxide and nitrogen have been used to combat typical subsurface landfill fires. When the inert gas is introduced into the subsurface under pressure, it cools the fuel and displaces the oxygen that is supporting combustion. Inert gases can be injected in a gaseous or liquid state. Injection of the gas as a liquid allows the material to transform from liquid to gas in the subsurface, providing additional cooling and driving force beyond the injection pressure as the liquid "boils" and the gas expands.

Liquid carbon dioxide (CO_2) is the preferred inert gas for subsurface injection. Liquid CO_2 is easier to work with than liquid nitrogen (N_2) because of the extreme temperatures of liquid nitrogen, which boils at -321 °F. Additionally, nitrogen is a typical parameter monitored to evaluate the presence of potential air intrusion at adjacent monitoring points. A gram-mole of liquid CO_2 at 25 degrees Celsius (°C) and 300 pounds per square inch (psi) will expand to 22.4 liters at standard temperature and pressure (STP) conditions (0 °C and 1 atmosphere). This is equivalent to about 8.2 cubic feet (ft^3) per pound or 16,433 ft^3 per ton of liquid CO_2.

The injection of inert gas has been successful in extinguishing subsurface oxidation (SSO) events, but it has not been successful in all cases. The challenge for the injection of inert gas is how to ensure that it is introduced into the landfill in such a manner so that it is uniformly distributed throughout the impacted materials. Municipal solid waste in a landfill is a non-heterogeneous material. Depending on the specific items and materials that make up the waste and the variability of the compaction effort, some denser areas may remain isolated from the gas. In these instances, the SSO event may rebound and, in the worst case scenario, continue to expand. In these cases, a repeat of the inert gas injection program or the application of other control measures may be required to remediate the SSO event.

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The injection of inert gas may have a negative impact on the gas collection and control system. Typically, the landfill gas (LFG) collection system would be turned off in the immediate vicinity of the injection activity. Alternatively, the landfill gas collection system will be turned off in a wider area extending beyond the impacted area during treatment. If part of the landfill gas collection system remains active, gas extraction wells near the injection area might be able to be used to "steer" the migration of the treatment gas. The downside of leaving the landfill gas collection system active near the treatment area would be the capture of a significant amount of the treatment gas. If the methane (and/or hydrogen and carbon monoxide) content is sufficiently reduced, the flare(s) could require supplemental fuel to burn. Bridgeton Landfill, LLC has a natural gas line connected to the flares that can be used to supplement the landfill gas and keep the flares operating if inert gas is drawn into the collection and control system.

4.0 SUMMARY

Based on the review of the site's current plan to address SSOs and evaluation of the use of inert gas injection, it is SCS's recommendation that the site continue to use its current plan to address SSOs and to have the inert gas as an a potential secondary option to address shallow SSOs.

5.0 SCS EXPERIENCE WITH ELEVATED TEMPERATURE LANDFILLS AND LANDFILL HOT SPOTS

SCS Engineers has significant experience with elevated temperature landfills and landfill hot spots. Landfill fires are often called subsurface oxidation events (or SSOs). These are usually localized and relatively shallow oxidation events that can elevate to the level of active combustion and fire. These are often caused or at least spread by an over-drawing or short circuiting gas collection and control system (GCCS). In this case, the GCCS system may pull atmospheric air and oxygen into the landfill, causing spontaneous combustion and thereafter fueling the SSO with additional quantities of oxygen from the surface above. These are different than working face fires that may develop from "hot loads" freshly deposited at the landfill's working face, where there is no existing cover material in place at all.

SCS has experience in investigating and extinguishing over 170 landfill fires or SSOs since the early 1980s and has published and presented on this topic for decades. The most common and effective approach to extinguishing an SSO or conventional landfill fire, and the one most commonly applied by SCS, is "cover and smother" by covering with fresh or additional soil cover, in an effort to prevent easy entry of the oxygen fueling the SSO. If a GCCS is operating nearby and may even have created the SSO, the GCCS can be throttled down or deactivated in the vicinity of the landfill fire. Other techniques applied often with incomplete success or reduced efficiency include inert gas injection and even excavation and removal of affected waste materials. SCS has applied inert gas injection on at least 6 landfills dating back to 1985.

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Appendix A

Corrective Action Plan Appendix D, Local Subsurface Oxidation (SSO – Potential Landfill Fire)

APPENDIX D

LOCAL SUBSURFACE OXIDATION PROCEDURE

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Appendix D

Local Subsurface Oxidation (SSO R Potential Landfill Fires)

Subsurface Oxidation Events (SSO) are common events that occur at many landfills that have active gas collection systems. These are local subsurface fires that are caused by a combination of subsurface conditions and well management. Unlike large subsurface reactions (which are extremely rare, do not require oxygen to propagate, and are quite different in nature), SSOs usually only involve a small area and a minimal number of gas wells.

In the North Quarry of the Bridgeton Landfill, it is important to distinguish between an isolated, readily-contained and easily-extinguished SSO from the advancement or initiation of a large subsurface reaction.

Typical Symptoms

- Dramatic localized landfill settlement.
- Charred or cracked surface cover.
- Stressed or dead vegetation in an area that is otherwise properly vegetated.
- Smoke or smoky odor emanating from the landfill surface or wellhead.
- Drastic or unusual increase in flowing gas temperature.
- Abnormal discoloration of wellhead/riser assembly.
- Abnormally high CO concentration in LFG.
- Deformed riser pipes.

Initial Notification and Investigation

Notify Environmental Manager immediately after visually identifying any potential SSO. An initial investigation shall be started within 12 hours after visual identification of a potential SSO.

1) Do not change the condition of the well during the initial investigation.

2) Health and Safety Considerations

   - Consult HASP for procedures related to landfill fires.
   - Under no circumstances shall an initial investigation be conducted without first consulting the HASP and implementing appropriate controls and procedures.
   - Do not breathe landfill gas or smoke. Stand upwind of emissions.
   - Wear appropriate PPE. Burns may be caused by hot PVC / HDPE / steel.
   - Do not drive heavy equipment / vehicles near well or depression until ground stability has been verified. *The burned waste mass may give way and equipment/personnel may fall into sinkhole.*

3) Conduct physical inspection

   a) Inspect the nearest extraction well to the potential SSO location.
   b) Inspect all wells within 500 feet of nearest extraction well to the potential SSO location.
   c) Inspect the landfill surface within 500 feet of nearest extraction well to the potential SSO location.

d) Visibly inspect for large localized settlement, cracks, holes, collapse, missing components, and areas that could be sources of air intrusion into the waste mass including:

- Monitoring ports
- Well casing
- Hoses
- Erosion ruts
- Dry soil cracks
- Manways
- Lift stations
- Sumps
- Leachate cleanout risers

4) Measure gas quality, pressure and temperature, at all wells within 500 feet of nearest extraction well to the potential SSO location. *Special precautions may be necessary to address high gas temperatures.*

5) Measure CO concentrations with colorimetric tubes (Draeger tubes) at all wells within 500 feet of nearest extraction well to the potential fire location, and obtain summa canister samples for laboratory CO analyses at all wells that indicate CO detections >500 ppm by colorimetric tube. *Gas temperature and other interference gasses can affect the accuracy of the measurement; therefore, the results of any CO field monitoring should be expressed qualitatively only.*

6) Infrared Thermometer Survey

- Use an IR laser thermometer to measure the temperature of the ground surface in the area of the suspected SSO. *Shallow fires or fires that have consumed large amounts of refuse will produce elevated surface temperatures. Extreme caution must be taken in these areas due to the possibility of the ground giving way.*

GGC^ L]P ZQPY NL`^POMd gZaP][WWYRh L RL^ bPWZ] bPWW TY L NP]_LTY L]PL) CcdRPY T^ O]LbY into the waste mass which can generate heat and provide the necessary oxygen for combustion. Since oxygen readings are collected as part of normal Title V, New Source Performance Standards (NSPS) monitoring, a review of the collected historical data from surrounding wells should be made. The data review should trend oxygen readings in from the wells in the general area of the SSO to determine if there was an overpull situation. Temperature should also be historically trended as heat; along with CO data (see below) is a good indicator of an SSO in the area.

Gas quality in wells adjacent to the SSO *may* be affected. In particular, carbon monoxide levels could elevate based on wellfield operation issues and preferred pathways within the waste mass. It is important to determine if the SSO is constrained to a single gas well and / or a single isolated area. Therefore, laboratory CO analyses will be expedited with results received within seven days of detection by colorimetric tube.

If the above investigation suggests that more than one gas well may be actively involved in an SSO area, then the investigation shall be expanded to include the wells within 500 feet of the SSO area.

Formal Notifications

The Environmental Manager shall notify the MDNR (SWMP Engineering Section Chief or Program Director at (573) 751-5401) within one business day of determination. The notification will include the gas well identification, date of initial detection, approximate area of the SSO, and results of initial investigation. The MDNR may observe or conduct confirmatory sampling.

Data Analysis

Determine the state of the SSO

- Analyze temperature gradient between monitored wells.
- Analyze oxygen gradient between monitored wells.
- Analyze nitrogen to oxygen ratio gradient between monitored wells. *If nitrogen is not measured directly, assume balance gas of nitrogen.*
- Analyze pressure gradient between monitored wells.
- Analyze methane to CO_2 ratio gradient between monitored wells.

Removing the Oxygen from the Fire

The key to stopping a SSO once it has begun is to completely restrict oxygen from entering the smoldering waste mass (snuff out the fire). Once the initial investigation has been performed and a general sense of the extent of the SSO has been determined, safely begin to restrict further oxygen intrusion using the following method:

1) Shutdown well(s) that is believed to have been the cause of the SSO.

2) Shutdown all wells in surrounding area (within the approximately 300 feet of suspect well(s)).

3) Cap or repair any item identified during the physical inspection that may be contributing to oxygen intrusion.

4) Carefully add additional cover to areas that show cap integrity issues if necessary. Work slowly and pay special attention to the ground surface as material placement commences.

    - During cover placement activities, there should be a minimum of two people available; the equipment operator, and a line-of-sight person on the ground that is responsible for watching the ground surface as the equipment operator places the soil.
    - Use a low ground pressure (LGP) machine, if available. If LGP machine is not available, use the lightest machine with the widest tracks available. Do not use rubber tired machine to place cover material.
    - Slowly push soil into the area and compact with the bucket or tracks of the equipment.

Note: Closing wellhead valves to minimize vacuum in the area of concern may cause vacuum levels to increase within the main header. This will redistribute the overall vacuum applied to the wellfield and may cause higher vacuums to other wells in the GCCS. Carefully watch for redistribution of vacuum, and adjust prime mover vacuum set-point accordingly. If greater than 10 percent of the total wells in the wellfield are closed to remediate the SSO, a complete retune of the wellfield may be warranted.

Things to Avoid

- *Flushing the well with water* L Flushing the well with water can potentially clog the well.
- *Excavating soil in the SSO area* L Do not excavate in the SSO area. Excavation will allow additional oxygen to enter the already smoldering waste mass and can potentially auto-ignite.
- Venting f Do not remove the wellhead to vent the well. Wellfields are typically under negative pressure. Residual vacuum exists in the waste mass for a period of time when wells are closed. If the wellhead is removed to vent, it is highly possible that the residual vacuum in the area will pull ambient air into the waste mass adding oxygen to the SSO.
- *Introduction of water into open cap fissures* L Applying water to open fissures in the cap where an SSO exists can create a plume of highly odorous stream. It is also dangerous to bring a heavy, rubber tired water truck to the area to apply water. The steam created can be dangerous to workers in the immediate area. If an open cap fissure exists in an SSO area, is shall be safely filled with soil. Removing the pathway for oxygen intrusion is the most effective way to put out the SSO.

Continued Monitoring

Monitor the wells closest to the suspected SSO area and adjacent wells at least once a day for at least two weeks.

- Monitor for gas quality, temperature, and CO. *As the SSO subsides, residual CO will remain in the waste mass for weeks and possibly months. Elevated CO levels are not a reliable indicator that an SSO is still in progress. However, CO levels should generally decline with time if the fire has been extinguished.*
- Once SSO indicators are no longer noted, monitor the well and adjacent wells once a week for at least 4 months before returning to normal monitoring schedule.

It is important that during these monitoring events the valve on the wellhead is opened for a prescribed time at a prescribed vacuum. This must be performed consistently form event to event to pull stagnant LFG form the well and fill the casing with fresh LFG form the Landfill formation. Analysis of this fresh LFG will provide the most realistic picture of the status of the SSO. Once readings are collected, the well must be returned to its closed position.

Repairs

Repairs should be made to the SSO area, as necessary

- Visual Inspection
- O&M Provider shall visually inspect the following:
  - % Wellheads and lateral piping,
  - % Cover soil and geosynthetics, and
  - % Other items within SSO area.
- Provide findings to, and generate repair options for OM&M Manager.
- OM&M Manager shall facilitate repairs, as required.

Timeline for Local SSO Resolution

It is important that a structured SSO monitoring plan and diligent adherence to the plan be carried out to return the wellfield to normal operation as soon as possible. However, it is advisable to take time and slowly ensure the SSO is fully extinguished and that the bacteria population in the area has recovered and is consistently producing gas.

The severity of the SSO, the age of the waste, moisture content, and a number of other variables will all determine how long it takes the wellfield to regain compliance with NSPS. Experience has shown that the timeline form the point when the SSO is identified and extinguished to the point when the wellfield resumes normal operation can vary from 2 to 3 weeks up to (in some serious SSO situations) 1 year or more.

Classification of the Event

The Environmental Manager and the MDNR will actively collaborate to verify and classify the SSO event. Such determination will be made within four weeks of the Initial Notification.

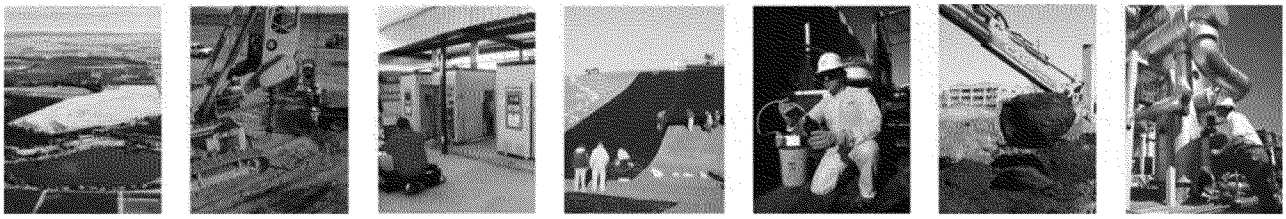
The event will be classified as a local SSO if monitoring indicates that combustion is constrained to one gas well and that there is no evidence that the SSO is enlarging.

If the event is not classified as a local SSO and may, instead, be considered a triggerable action per the North Quarry Contingency Plan, then Bridgeton Landfill and the MDNR will discuss and reach agreement on the appropriate action which may include further monitoring or entering into the path of actions provided in Table 1 of the North Quarry Contingency Plan f Part 1.

Appendix B

Inert Gas Injection Work Plan

SCS ENGINEERS



Corrective Action Measures

Inert Gas Injection Work Plan for Hot Spot Remediation

Presented to:

Bridgeton Landfill, LLC
13570 St. Charles Rock Road
Bridgeton, Missouri 63044
(314) 744-8166

Presented by:

SCS ENGINEERS
2060 Reading Road, Suite 200
Cincinnati, Ohio 45202
(513) 421-5353

September 9, 2015
File No. 23211003.04

Offices Nationwide
www.scsengineers.com

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Appendices

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1.0 INTRODUCTION

In their letter dated August 10, 2015, the Missouri Department of Natural Resources (DNR) requested that Bridgeton Landfill, LLC prepare a Corrective Measures Work Plan that includes:

> *"...a corrective action measure using inert gas injection as a "hot spot" treatment."*

This report presents the specifically requested Corrective Measures Work Plan.

Appendix D of the November 2014 Corrective Action Plan describes the identification of and remedial actions for local subsurface oxidation (SSO). As described in Appendix D:

> *"Subsurface Oxidation Events (SSO) are common events that occur at many landfills that have active gas collection systems. These are local subsurface fires that are caused by a combination of subsurface conditions and well management. Unlike large subsurface reactions (which are extremely rare, do not require oxygen to propagate, and are quite different in nature), SSOs usually only involve a small area and a minimal number of gas wells."*

If the actions described in Appendix D of the November 2014 Corrective Action Plan are unsuccessful in controlling the SSO, inert gas injection may be implemented to remediate the SSO event.

2.0 INERT GAS INJECTION BACKGROUND

Carbon dioxide and nitrogen have been used to combat typical subsurface landfill fires. When the gas is introduced into the subsurface under pressure, it cools the fuel and displaces the oxygen that is supporting combustion. Inert gases can be injected in a gaseous or liquid state. Injection of the gas as a liquid allows the material to transform from liquid to gas in the subsurface, providing additional cooling and driving force beyond the injection pressure as the liquid "boils" and the gas expands.

Liquid carbon dioxide (CO_2) is the preferred inert gas for subsurface injection. Liquid CO_2 is easier to work with than liquid nitrogen (N_2) because of the extreme temperatures of liquid nitrogen, which boils at -321 °F. Additionally, nitrogen is a typical parameter monitored to evaluate the presence of potential air intrusion at adjacent monitoring points. A gram-mole of liquid CO_2 at 25 degrees Celsius (°C) and 300 pounds per square inch (psi) will expand to 22.4 liters at standard temperature and pressure (STP) conditions (0 °C and 1 atmosphere). This is equivalent to about 8.2 cubic feet (ft^3) per pound or 16,433 ft^3 per ton of liquid CO_2.

The injection of inert gas has been successful in extinguishing subsurface oxidation (SSO) events, but it has not been successful in all cases. The challenge for the injection of inert gas is how to ensure that it is introduced into the landfill in such a manner so that it is uniformly distributed throughout the impacted materials. Municipal solid waste in a landfill is a non-heterogeneous material. Depending on the specific items and materials that make up the waste

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and the variability of the compaction effort, some denser areas may remain isolated from the gas. In these instances, the SSO event may rebound and, in the worst case scenario, continue to expand. In these cases, a repeat of the inert gas injection program or the application of other control measures may be required to remediate the SSO event.

The injection of inert gas may have a negative impact on the gas collection and control system. Typically, the landfill gas (LFG) collection system would be turned off in the immediate vicinity of the injection activity. Alternatively, the landfill gas collection system will be turned off in a wider area extending beyond the impacted area during treatment. If part of the landfill gas collection system remains active, gas extraction wells near the injection area might be able to be used to "steer" the migration of the treatment gas. The downside of leaving the landfill gas collection system active near the treatment area would be the capture of a significant amount of the treatment gas. If the methane (and/or hydrogen and carbon monoxide) content is sufficiently reduced, the flare(s) could require supplemental fuel to burn. Bridgeton Landfill has a natural gas line connected to the flares that can be used to supplement the landfill gas and keep the flares operating if inert gas is drawn into the collection and control system.

Inert gas injection is not a recommended remedial strategy for the subsurface event (SSE) reaction that exists in the South Quarry portion of the landfill. The SSE is not fire and does not require oxygen to support the chemical reactions that are occurring. The injection of inert gas would not interrupt these chemical reactions. Other than a potential slowing of the reactions due the temporary cooling effect of the gas, the injection of inert gas will not end the SSE. Even if the inert gas could have an impact on the chemical reaction driving the SSE, the waste at depth is denser, increasing the difficulty of ensuring the gas is in direct contact will all the waste.

Therefore, inert gas injection technology is not appropriate for large, deep, area-wide reactions nor for conventional landfill fires (or SSOs) deeper than 30 feet

3.0 INERT GAS INJECTION FIELD PROGRAM

The following sections describe in general terms a program of inert gas injection. A program specific to the conditions encountered for an individual SSO event should be developed.

3.1 IDENTIFICATION OF AFFECTED AREA

The affected area must be delineated in order to design an effective injection plan. The Bridgeton Landfill, LLC Environmental Manager and the MDNR will actively collaborate to verify and classify the SSO event. Such determination will be made within four weeks of the Initial Notification. The event will be classified as a local SSO if monitoring indicates that combustion is constrained to one gas well and that there is no evidence that the SSO is enlarging. The Bridgeton Landfill will begin to implement their standard procedures to remediate an SSO as described in the Corrective Action Plan Appendix D, Local Subsurface Oxidation (SSP – Potential Landfill Fire), attached to this document as Appendix A. The Environmental Manager and the MDNR will actively collaborate to determine if and when inert gas injection should be performed.

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3.1.1 Surface Observations

As described in Appendix D of the November 2014 Corrective Action Plan, typical symptoms of a SSO event include:

- Dramatic localized landfill settlement.
- Charred or cracked surface cover.
- Stressed or dead vegetation in an area that is otherwise properly vegetated.
- Smoke or smoky odor emanating from the landfill surface or wellhead.
- Drastic or unusual increase in flowing gas temperature.
- Abnormal discoloration of wellhead/riser assembly.
- Abnormally high carbon monoxide (CO) concentration in LFG.
- Deformed riser pipes.

To further define the area of the SSO event, a ground-based infrared (IR) thermometer survey should be performed. Use a hand-held IR laser thermometer (or equivalent device) to measure the temperature of the ground surface in area where an SSO event is suspected. Shallow fires or fires that have consumed large amounts of refuse will produce elevated surface temperatures. Extreme caution must be taken in these areas due to the possibility of the ground giving way. The area should be marked with caution tape to prevent individuals from walking or driving in the area of concern.

3.1.2 Subsurface Investigation

In order to design the injection point array to maximize the effect of the inert gas, the vertical location and extent of the SSO event should be defined. Given that the gas will tend to flow towards the lower atmospheric pressure at the ground surface, the injection points should be located at or just below the base of the SSO event area. The following methods can be used to evaluate the vertical extent of the SSO event.

3.1.2.1 Downhole temperature monitoring

If one or more gas extraction wells are present in the SSO event area, downhole temperature measurements can be made in these wells.

It should be noted that the procedures below may expose the observer to significant risks, including but not limited to:

- Explosive concentrations of methane.
- High concentrations of volatile organic compounds (VOCs).
- High temperature gas.
- High temperature well components.

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The vacuum to the well should be shut off or reduced significantly to prevent the introduction of large quantities of air into the collection system. Depending on the well head construction, open an access port or remove the well head. Lower a thermocouple into the well and record the temperature at 5-foot intervals below the surface. SSO events are typically shallow, so the measurements should not extend below 50 ft and should not be performed below the liquid level in the well.

3.1.2.2 Thermocouple Array Installation

In situ subsurface temperature measurements can be made by installing arrays of thermocouples at regular depth intervals below the surface. The thermocouple arrays cannot be installed within the actual area of combustion of the SSO event, but can be installed outside the area of combustion to evaluate the vertical distribution of heat from the combustion. The arrays will be installed using Direct Push Technology (DPT) drilling methods. The DPT drill pipe will be advanced to the target depth with a disposable point. The arrays will consist of thermocouples attached to a solid spine of plastic or fiberglass rod. The thermocouples will be attached to the spine at 5-foot intervals with electrical tape. The wires will be secured to the spine above each of the thermocouples. The wire leads will be clearly labelled to identify the depth of burial of each of the thermocouples. The spine and thermocouple array will be placed in the drill rod. The drill rod will be withdrawn and the annulus between the borehole and the array will be filled with bentonite grout. The grout is intended to isolate the thermocouples by preventing hot gases from moving within the annulus. The surface at each array will be completed with an 18-inch thick concrete surface seal.

A vertical support will be placed into the surface seal. A weather proof box will be attached to the vertical support. The thermocouple wire terminals will be accessed inside the box. The spine and thermocouple wires have been known to act as a preferred pathway for landfill gas. Gas leaking around the wires may have to be addressed with additional bentonite and/or soil.

3.2 GAS INJECTION POINT INSTALLATION

Gas injection points (GIPs) will be installed using DPT drilling techniques. The injection points will be installed at standard 25 foot depth below the surface, unless investigations have been performed to determine the vertical extent. The gas injection points will consist of a dedicated 2-inch diameter DPT drill tooling (pipe) with ¼-inch holes drilled around the bottom two feet of the pipe. The holes will be spaced at approximately 2 inches apart in order to not overly weaken the pipe prior to installation. The surface at each injection point will be completed with an 18-inch thick concrete surface seal. For injection and pre-injection gas sampling the points will be fitted with a conversion from A-P drill thread to national pipe thread (NPT).

The top of the injection point will be fitted with a 90-degree elbow and a stainless steel, quarter turn ball valve. In addition, the top of the injection point will be fitted with either a pressure gage and/or a self-sealing quick connect to allow a pressure measurements (and gas measurements) to be made using a GEM or similar instrument. Coordinate with the CO_2 supplier to determine what the final connection should be to be compatible with the tanker truck delivery hoses.

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For conservativeness, the radius of influence of each point has been estimated to be approximately 15 feet. Therefore, an array of injection points on a roughly 25-foot grid should be installed over the identified SSO event area. The grid should extend beyond the SSO event area, with a minimum of one injection point located outside the identified SSO event area on all sides.

3.3 INJECTION OF INERT GAS

As described above, it is estimated that each well will have a radius of influence of approximately 15 feet. Each injection point will consist of a 2-foot long perforated section of pipe and is estimated to influence approximately 5 feet vertically. An assumption of approximately 25 percent void space in the refuse mass was used to determine the volume of liquid CO_2 needed for a single well. The estimated liquid CO_2 utilized per injection point is 884 ft^3, or 108 pounds of liquid CO_2.

Liquid CO_2 injection will be performed over a one-day period. Liquid CO_2 will be delivered to the Site via tanker truck. Access to the SSO area suitable for the tanker truck must be prepared. At each well location, the liquefied CO_2 supplier will connect directly to the gas injection point, and deliver approximately 108 pounds of liquefied CO_2. Note that it will be difficult to determine the exact amount of liquid CO_2 injected into each point due to the nature of the liquid CO_2 delivery (via tanker truck), therefore close attention will be paid to back pressure on the injection point, CO_2 and pressure influence on adjacent monitoring locations, and temperature fluctuations at the temperature monitoring points (if installed). The liquid CO_2 will be targeted for injection at pressures between 200 and 300 psi. This range has been selected due to higher pressures having the potential for causing ground upheaval and because, at pressures lower than approximately 75 psi, CO_2 will become a solid.

The injection will begin at the outer gas injection points and work inward to the center of the suspected combustion zone. This will minimize the potential for forcing heat outward from the combustion zone into adjacent areas. A Health and Safety Plan will be prepared to cover the inert gas injection activities and will be attached to this work plan prior to implementation. Special hazards include the risk of suffocation due to the displacement of oxygen and the risk of frostbite from super cooled gas, hoses, and piping.

Up to four rounds of injections are anticipated under the following scenario:

- Initial injection and monitoring overnight to determine the need for additional injection based on real-time monitoring of subsurface temperatures at the thermocouple locations.
- Additional injection on the second day, as needed.
- Temperature monitoring for one week and evaluation of need for additional injection (this may include evaluation of the need for additional injection points).
- Third injection within 24-72 hours, if needed.
- Weekly temperature monitoring for up to four weeks.

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- If rebounding occurs after the third injection, a fourth injection will be implemented within 24-72 hours.
- Weekly temperature monitoring for up to four weeks.

Subsequent injections following the first day may be targeted at specific GIP locations rather than repeated injections at all GIP locations.

3.4 MONITORING

Monitoring must be performed during injection. Monitoring must also be performed after the injection has been completed to evaluate long term effect of the gas injection.

3.4.1 Injection Monitoring

The observer will look for any visual or audible signs of short circuiting; including surface cracking, gas release indicated by the discharge of soil particles or plumes of condensation from cold gas, or hissing noises. Potential leakage around the edges of the temporary cover and near thermocouple and injection points completed through the cover will also be monitored for VOCs using a hand-held FID and for CO_2 using a GEM 5000 (or equivalent).

Unused injection points will be monitored to ascertain if CO_2 gas has extended to the adjacent points as well as to monitor the gas within the zone of concern.

If they have been installed, temperature probes will be monitored prior to, during, and after each liquid CO_2 injection.

3.4.2 Performance Monitoring

After liquid CO_2 injection, the temperature points will be monitored for rebound of temperatures above 170 °F that may occur over the following month to determine the effectiveness of the liquid CO_2 injection at suppressing the elevated temperatures at the site. Generally, temperatures are expected to either rebound to former higher levels or stabilize at the lower temperatures within several days after injection. Temperature readings will be recorded continuously at 1-hour intervals throughout and after the gas injection by the existing thermocouple array. The thermocouple data will be read continuously until a few hours after injection, at least once on the following day, and on a weekly basis thereafter until it has been determined that temperatures have stabilized and there is little potential for re-ignition of the prior combustion.

In the event that elevated temperatures are not abated, a re-injection and/or expansion of the liquid CO_2 injection area may be required as discussed above.

If rebounding does not occur within four weeks following the second, third or fourth injections, the fire will be considered to be extinguished. If rebound occurs after the fourth injection, additional work will be warranted.

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4.0 SCHEDULE

The schedule discussed within does not include the time to initially identify the SSO or the initial remedial efforts consistent with the oxygen deprivation approach described in Appendix D of the Corrective Action Plan. This schedule begins when the decision has been made that the initial oxygen deprivation remediation program has not adequately addressed the SSO.

During month one, any additional effort to verify the areal and/or vertical extent of the SSO will be performed. During this time, the array of GIPs will be designed and installed. Also a supplier of inert gas will be identified and placed under contract. During month two, the gas injection(s) will be performed. Month three will consist of performance monitoring to verify that the SSO has been successfully remediated.

5.0 REPORTING

Weekly Status Updates will be provided via email throughout the period for implementation of this work plan. Status Updates will include discussion of on-Site activities during the previous week, summary of data and findings, and planned activities for the following week. The Status Updates will be provided by close of business on Monday of the following week.

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Appendix A

Corrective Action Plan Appendix D, Local Subsurface Oxidation (SSO – Potential Landfill Fire)

APPENDIX D

LOCAL SUBSURFACE OXIDATION PROCEDURE

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Appendix D

Local Subsurface Oxidation (SSO R Potential Landfill Fires)

Subsurface Oxidation Events (SSO) are common events that occur at many landfills that have active gas collection systems. These are local subsurface fires that are caused by a combination of subsurface conditions and well management. Unlike large subsurface reactions (which are extremely rare, do not require oxygen to propagate, and are quite different in nature), SSOs usually only involve a small area and a minimal number of gas wells.

In the North Quarry of the Bridgeton Landfill, it is important to distinguish between an isolated, readily-contained and easily-extinguished SSO from the advancement or initiation of a large subsurface reaction.

Typical Symptoms

- Dramatic localized landfill settlement.
- Charred or cracked surface cover.
- Stressed or dead vegetation in an area that is otherwise properly vegetated.
- Smoke or smoky odor emanating from the landfill surface or wellhead.
- Drastic or unusual increase in flowing gas temperature.
- Abnormal discoloration of wellhead/riser assembly.
- Abnormally high CO concentration in LFG.
- Deformed riser pipes.

Initial Notification and Investigation

Notify Environmental Manager immediately after visually identifying any potential SSO. An initial investigation shall be started within 12 hours after visual identification of a potential SSO.

1) Do not change the condition of the well during the initial investigation.

2) Health and Safety Considerations

   - Consult HASP for procedures related to landfill fires.
   - Under no circumstances shall an initial investigation be conducted without first consulting the HASP and implementing appropriate controls and procedures.
   - Do not breathe landfill gas or smoke. Stand upwind of emissions.
   - Wear appropriate PPE. Burns may be caused by hot PVC / HDPE / steel.
   - Do not drive heavy equipment / vehicles near well or depression until ground stability has been verified. *The burned waste mass may give way and equipment/personnel may fall into sinkhole.*

3) Conduct physical inspection

   a) Inspect the nearest extraction well to the potential SSO location.
   b) Inspect all wells within 500 feet of nearest extraction well to the potential SSO location.
   c) Inspect the landfill surface within 500 feet of nearest extraction well to the potential SSO location.

d) Visibly inspect for large localized settlement, cracks, holes, collapse, missing components, and areas that could be sources of air intrusion into the waste mass including:

- Monitoring ports
- Well casing
- Hoses
- Erosion ruts
- Dry soil cracks
- Manways
- Lift stations
- Sumps
- Leachate cleanout risers

4) Measure gas quality, pressure and temperature, at all wells within 500 feet of nearest extraction well to the potential SSO location. *Special precautions may be necessary to address high gas temperatures.*

5) Measure CO concentrations with colorimetric tubes (Draeger tubes) at all wells within 500 feet of nearest extraction well to the potential fire location, and obtain summa canister samples for laboratory CO analyses at all wells that indicate CO detections >500 ppm by colorimetric tube. *Gas temperature and other interference gasses can affect the accuracy of the measurement; therefore, the results of any CO field monitoring should be expressed qualitatively only.*

6) Infrared Thermometer Survey

- Use an IR laser thermometer to measure the temperature of the ground surface in the area of the suspected SSO. *Shallow fires or fires that have consumed large amounts of refuse will produce elevated surface temperatures. Extreme caution must be taken in these areas due to the possibility of the ground giving way.*

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Gas quality in wells adjacent to the SSO *may* be affected. In particular, carbon monoxide levels could elevate based on wellfield operation issues and preferred pathways within the waste mass. It is important to determine if the SSO is constrained to a single gas well and / or a single isolated area. Therefore, laboratory CO analyses will be expedited with results received within seven days of detection by colorimetric tube.

If the above investigation suggests that more than one gas well may be actively involved in an SSO area, then the investigation shall be expanded to include the wells within 500 feet of the SSO area.

Formal Notifications

The Environmental Manager shall notify the MDNR (SWMP Engineering Section Chief or Program Director at (573) 751-5401) within one business day of determination. The notification will include the gas well identification, date of initial detection, approximate area of the SSO, and results of initial investigation. The MDNR may observe or conduct confirmatory sampling.

Data Analysis

Determine the state of the SSO

- Analyze temperature gradient between monitored wells.
- Analyze oxygen gradient between monitored wells.
- Analyze nitrogen to oxygen ratio gradient between monitored wells. *If nitrogen is not measured directly, assume balance gas of nitrogen.*
- Analyze pressure gradient between monitored wells.
- Analyze methane to CO_2 ratio gradient between monitored wells.

Removing the Oxygen from the Fire

The key to stopping a SSO once it has begun is to completely restrict oxygen from entering the smoldering waste mass (snuff out the fire). Once the initial investigation has been performed and a general sense of the extent of the SSO has been determined, safely begin to restrict further oxygen intrusion using the following method:

1) Shutdown well(s) that is believed to have been the cause of the SSO.

2) Shutdown all wells in surrounding area (within the approximately 300 feet of suspect well(s)).

3) Cap or repair any item identified during the physical inspection that may be contributing to oxygen intrusion.

4) Carefully add additional cover to areas that show cap integrity issues if necessary. Work slowly and pay special attention to the ground surface as material placement commences.

    - During cover placement activities, there should be a minimum of two people available; the equipment operator, and a line-of-sight person on the ground that is responsible for watching the ground surface as the equipment operator places the soil.
    - Use a low ground pressure (LGP) machine, if available. If LGP machine is not available, use the lightest machine with the widest tracks available. Do not use rubber tired machine to place cover material.
    - Slowly push soil into the area and compact with the bucket or tracks of the equipment.

Note: Closing wellhead valves to minimize vacuum in the area of concern may cause vacuum levels to increase within the main header. This will redistribute the overall vacuum applied to the wellfield and may cause higher vacuums to other wells in the GCCS. Carefully watch for redistribution of vacuum, and adjust prime mover vacuum set-point accordingly. If greater than 10 percent of the total wells in the wellfield are closed to remediate the SSO, a complete retune of the wellfield may be warranted.

Things to Avoid

- *Flushing the well with water* L Flushing the well with water can potentially clog the well.
- *Excavating soil in the SSO area* L Do not excavate in the SSO area. Excavation will allow additional oxygen to enter the already smoldering waste mass and can potentially auto-ignite.
- Venting f Do not remove the wellhead to vent the well. Wellfields are typically under negative pressure. Residual vacuum exists in the waste mass for a period of time when wells are closed. If the wellhead is removed to vent, it is highly possible that the residual vacuum in the area will pull ambient air into the waste mass adding oxygen to the SSO.
- *Introduction of water into open cap fissures* L Applying water to open fissures in the cap where an SSO exists can create a plume of highly odorous stream. It is also dangerous to bring a heavy, rubber tired water truck to the area to apply water. The steam created can be dangerous to workers in the immediate area. If an open cap fissure exists in an SSO area, is shall be safely filled with soil. Removing the pathway for oxygen intrusion is the most effective way to put out the SSO.

Continued Monitoring

Monitor the wells closest to the suspected SSO area and adjacent wells at least once a day for at least two weeks.

- Monitor for gas quality, temperature, and CO. *As the SSO subsides, residual CO will remain in the waste mass for weeks and possibly months. Elevated CO levels are not a reliable indicator that an SSO is still in progress. However, CO levels should generally decline with time if the fire has been extinguished.*
- Once SSO indicators are no longer noted, monitor the well and adjacent wells once a week for at least 4 months before returning to normal monitoring schedule.

It is important that during these monitoring events the valve on the wellhead is opened for a prescribed time at a prescribed vacuum. This must be performed consistently form event to event to pull stagnant LFG form the well and fill the casing with fresh LFG form the Landfill formation. Analysis of this fresh LFG will provide the most realistic picture of the status of the SSO. Once readings are collected, the well must be returned to its closed position.

Repairs

Repairs should be made to the SSO area, as necessary

- Visual Inspection
- O&M Provider shall visually inspect the following:
  - % Wellheads and lateral piping,
  - % Cover soil and geosynthetics, and
  - % Other items within SSO area.
- Provide findings to, and generate repair options for OM&M Manager.
- OM&M Manager shall facilitate repairs, as required.

Timeline for Local SSO Resolution

It is important that a structured SSO monitoring plan and diligent adherence to the plan be carried out to return the wellfield to normal operation as soon as possible. However, it is advisable to take time and slowly ensure the SSO is fully extinguished and that the bacteria population in the area has recovered and is consistently producing gas.

The severity of the SSO, the age of the waste, moisture content, and a number of other variables will all determine how long it takes the wellfield to regain compliance with NSPS. Experience has shown that the timeline form the point when the SSO is identified and extinguished to the point when the wellfield resumes normal operation can vary from 2 to 3 weeks up to (in some serious SSO situations) 1 year or more.

Classification of the Event

The Environmental Manager and the MDNR will actively collaborate to verify and classify the SSO event. Such determination will be made within four weeks of the Initial Notification.

The event will be classified as a local SSO if monitoring indicates that combustion is constrained to one gas well and that there is no evidence that the SSO is enlarging.

If the event is not classified as a local SSO and may, instead, be considered a triggerable action per the North Quarry Contingency Plan, then Bridgeton Landfill and the MDNR will discuss and reach agreement on the appropriate action which may include further monitoring or entering into the path of actions provided in Table 1 of the North Quarry Contingency Plan f Part 1.